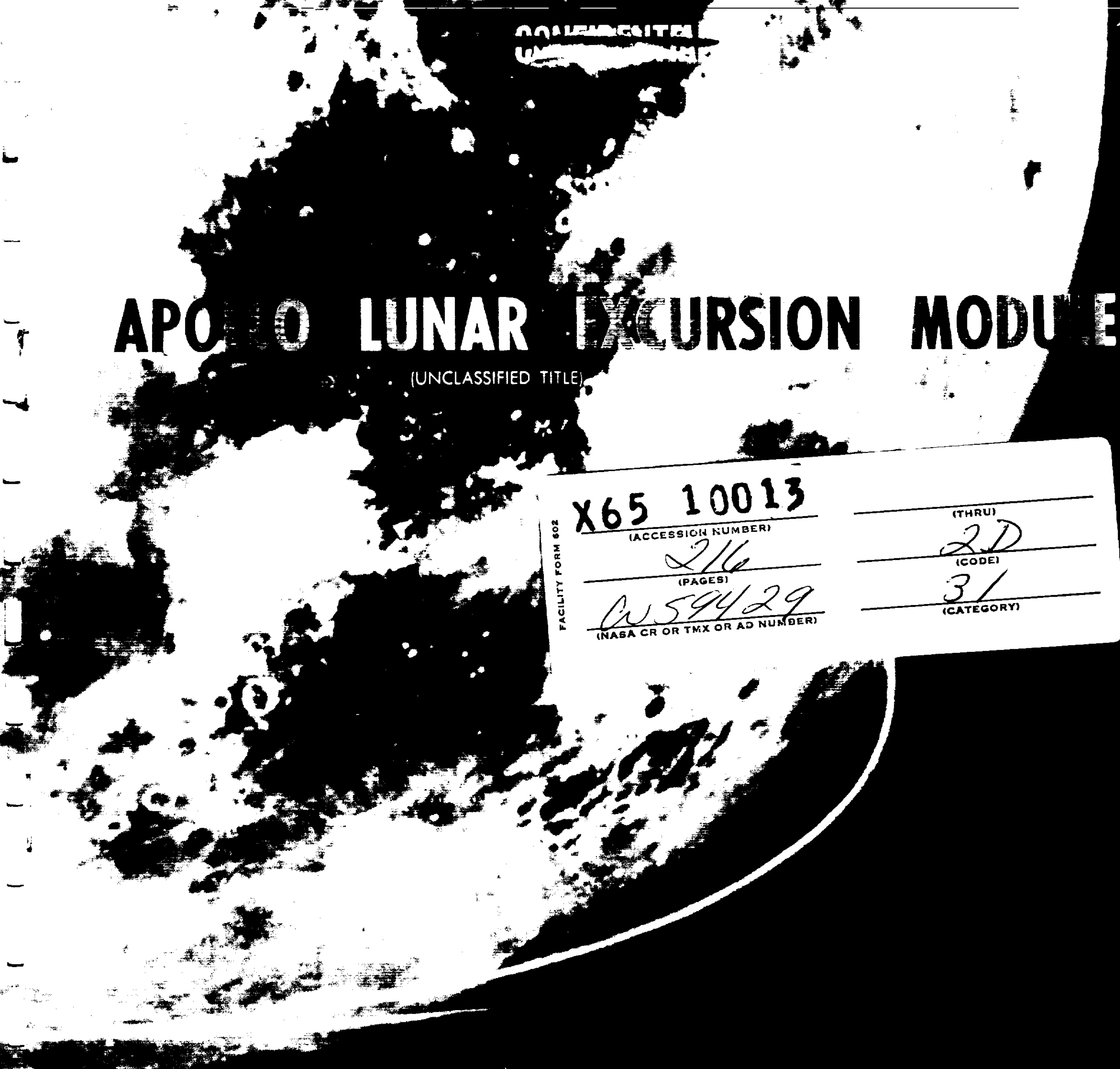


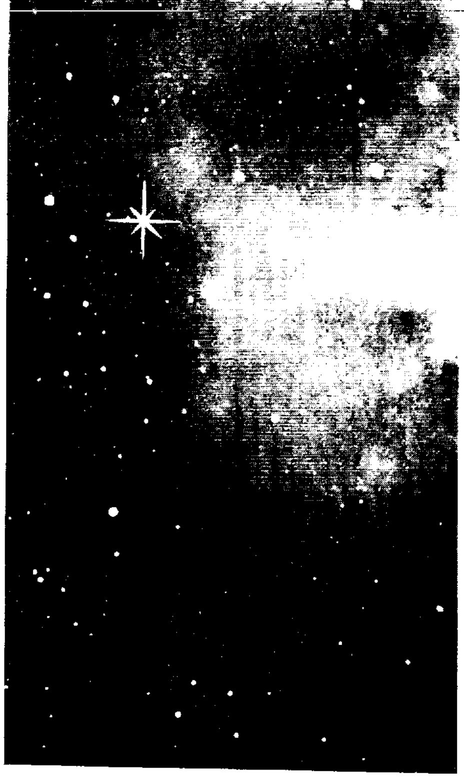
APOLLO LUNAR EXCURSION MODULE

(UNCLASSIFIED TITLE)

GRUMMAN R-[illegible]

QUALITY ASSURANCE AND RELIABILITY

ROCKETDYNE • A DIVISION OF NORTH AMERICAN AVIATION, INC



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GRUMMAN AIRCRAFT ENGINEERING CORPORATION

APOLLO LUNAR EXCURSION MODULE

(Quality Assurance and Reliability)

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Space Engines
Quality Assurance and Reliability
Canoga Park, California

Robert L. Heath

R. L. Heath
Director
Quality and Reliability
Rocketdyne

17 August 1962

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FOREWORD

This technical report accompanies a proposal submitted in response to the Grumman Aircraft Engineering Corporation, Long Island, New York, in response to Request for Proposal No. T-502705, dated 6 August 1962.

ABSTRACT

A Quality Assurance plan and a Reliability program for performance under the applicable Grumman requirements are presented. Included are statements of policies and objectives, a description of the operating plan, and procedures for accomplishing the plan. Detail examples of Rocketdyne inspection, specification, engine log, instrumentation, and control stamp books and forms are appended. Uncl.

(Unclassified Abstract)

CONTENTS

INTRODUCTION

The quality assurance and reliability programs of Rocketdyne are integrated with respect to policy guidance through the director of Quality Assurance and Reliability.

Because of the intensive requirements for reliability at the point where reliability must originate--in Design Engineering, the reliability organization reports to an engineering manager who reports to the chief engineer. The reliability program has been written separately in order to define its functions precisely.

The manager of Quality Assurance reports directly to the manager of the Rocketdyne product operation in order to provide strength and effective management to this vital function. The quality assurance plan, like the reliability plan, is presented separately because of the specialized position of this function in Rocketdyne management.

This is not to say that the only coordination and integration is accomplished through the policy guidance of the director of Quality and Reliability. Coordination of these basic functions takes place on many levels of the overall Rocketdyne operations, as illustrated by the activities of the various reliability working committees described in these plans and by the details in the quality control manuals, which contain procedures that implement the quality control system.

The following information is submitted in response to and in accordance with the instructions outlined in The Boeing Company General Proposal Instructions for LEM, Page 6, "Quality Control Requirements".

1. It is estimated that approximately 30 (average per month) quality control personnel will be assigned to this program.

2. The ratio of quality control production personnel to manufacturing production personnel applicable on this program is estimated at approximately 1:5 respectively. This ratio applies to all fabrication, shipping, and associated manufacturing operations.

3. There are several quality control management types who will be associated with this program. The management structures and organizational levels for the quality control operation are described in the Quality Assurance Plan for The Boeing Company, Figures 1,2,3, and 4.

4. A Quality Control Management resume is contained within the content of The Boeing Quality Assurance Plan under the heading of "Management Structure" (2.1). Personal resumes of Quality Control Management personnel are contained in other portions of the Management Proposal.

   Skill levels of quality control personnel that will be assigned to this program are referred to within the contents of The Boeing Company Quality Assurance Plan.

RELIABILITY PROGRAM

The Rocketdyne reliability program is based upon the thesis that careful and thorough performance of certain disciplines and tasks leads to a more efficient attainment of reliability in liquid rocket propulsion systems. These disciplines are mandatory for the high reliability requirements of the LEM.

Reliability improvement can only be attained by action with constructive influence on the design, manufacture, or use of the propulsion system. With strong emphasis on this, some of the more important facets of the reliability program at Rocketdyne are described in detail to indicate that Rocketdyne employs a wide spectrum of reliability disciplines, and to discuss specific application to propulsion systems as developed by Rocketdyne. An integrated program, from concept to use, is first outlined to show the manner in which the various tasks supplement and support each other.

REPORT ORGANIZATION

Management, Organization, understanding, and support of the reliability program on the part of Management are discussed first because of their importance in the areas of design, manufacture, and use.

Training, both educational and motivational, is discussed separately for the same reason.

Reliability Analysis, Prediction and Model, evaluating all available data from past experience, estimates the reliability that may be attained by a careful development program of the scope defined by requirements, budget, and schedule. Construction and analysis of a reliability model focuses attention on critical areas and often suggests design improvements.

Malfunction Analysis, again using all past experience and knowledge of requirements and environment, analyzes the design for potential modes of failure. This is helpful in the Reliability Analysis function. It is used in design review and in planning development tests.

In the design phase, much information in usable form is provided the engineers. Subjects with a strong emphasis on design are discussed before secondary topics, such as data.

Human Factors Engineering involves the systematic consideration of man/machine interaction problems and their alleviation by design and procedural improvements. This group is directly involved in reliability motivation, systems testing, personnel subsystem development, and other reliability improvement efforts.

Maintainability includes the human factors consideration, but goes further with a strong drive to decrease maintenance requirements. Many reliability analysis techniques are applied to maintainability, and the two subjects are further coordinated in Design Review. Maintainability is considered in the design phase of the engine program to ensure that it is part of the original engine system concept. It is therefore discussed under Design Review. Additional tasks are discussed under Logistics.

Value Engineering, a systematic and imaginative consideration of how the required functions may best be achieved, not only reduces costs, but the attendant simplification often benefits reliability.

Hardware Protection (Packaging), Drawing Review, Production Design considerations, and Specification and Standards review and coordination are described.

Design Review, a meticulous assurance that the design requirements are understood and that all possible use is made of past experience (malfunction analysis, checklists, etc.).

The separate section on Quality Control describes the effort and controls to obtain hardware consistent with the design as expressed by drawings and specifications. Vendor controls, for example, are discussed in detail, so will not be repeated under the Reliability Program other than to ensure that management provisions exist for thorough coordination and reporting. Additional effort by the Reliability Group is illustrated by the following.

Reliability Testing discusses basic philosophy of development and qualification testing.

Statistical Test Design techniques for efficient planning and analysis of these tests are used throughout the program. This discipline is a powerful tool in unifying concepts and their applications, failure modes, environments, overstress testing, evaluating reliability progress, etc.

Reliability Assurance requires special discussion due to the difficulty of obtaining statistical confidence for very high reliability values. Overstress testing concepts are discussed as an efficient method of obtaining this assurance.

Data Reporting and Analysis systems are required to retain large quantities of valuable data and permit digesting, analyzing, and reporting it to those who must see that it is incorporated into improved design, manufacture, or use.

<u>Failure Analysis</u> effort is applied to all failures experienced, running the gamut from laboratory analysis of failed hardware, to human errors in working with the hardware. A strong effort is made to trace the fault beyond secondary results to the original cause. Problem followup status is maintained.

<u>Failure Recurrence Control</u> then seeks to correct the fault, or lack, that permitted the error, often requiring training, procedures, or management controls. This must be established in a form so that the experience is retained.

The third area of control to increase achieved reliability, Use, is discussed in the Logistics section. Specific contributions of the Reliability Group are discussed under Human Factors, Maintainability, etc. The efforts of both groups are closely coordinated; the Reliability Group, for example, maintains a common failure data system.

RELIABILITY PROGRAM MANAGEMENT

Reliability is a management responsibility. The broad scope of a reliability program requires definite provisions for policy direction, procedures, and coordination, and for monitoring the reliability efforts of all departments concerned. This is accomplished by the following organization.

The Rocketdyne Reliability Policy Board, with the Rocketdyne president, executive vice-president, and major division heads as members (Fig. 1), is responsible for policy direction, and creating a receptive atmosphere so that necessary procedures and controls may be instituted.

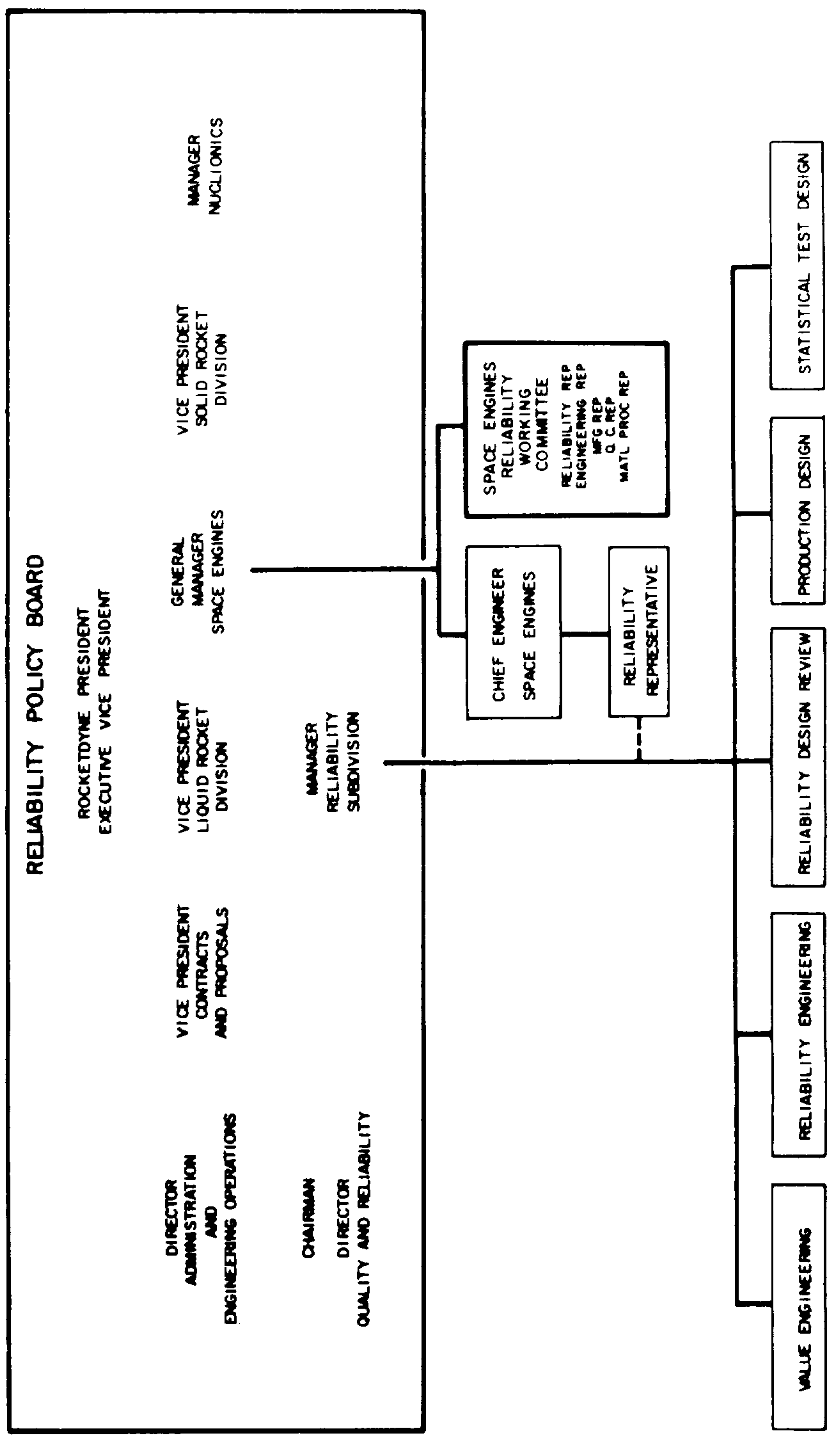

Figure 1. Reliability Policy Board

The director of Quality and Reliability is specifically responsible for these functions, coordinating and monitoring the reliability program of the various Rocketdyne divisions.

Space Engines Product Operation

The manager of the Space Engines Division, responsible for the design and development of the LEM, has appointed a Reliability representative reporting directly to the chief engineer.

The Reliability representative, together with the Reliability Central Group, translates the LEM reliability objectives into a reliability program. He defines tasks and schedules, allots budgets, monitors progress, and reports to management on status or requirements of the reliability program. When action is required on reliability problems, the representative has the authority to secure action from various groups within Rocketdyne to resolve these problems. Where it is necessary to accomplish special objectives, task groups are formed within the existing line organization. Any delegation of assignments of this nature by the Reliability representative are accomplished through the various functional division heads. He is charman of the Reliability Working Group.

The Space Engines Reliability Working Group, with members at the working level from each department (Fig. 1), meet regularly to effect action in those areas requiring coordination among the various departments. Each representative reports directly to his department head, and minutes of the meetings are sent to all Reliability Policy Board members.

Implementation of the Space Engines reliability and maintainability efforts is allocated to the Reliability Subdivision for execution

Reliability Subdivision

The Reliability Subdivision is a part of the Rocketdyne Engineering Department, and, as a central group of all Rocketdyne reliability activities, is in the strategic position to influence and direct reliability activities from the initial concept through design, development, product manufacture, and acceptance, to its usage by the customer. The Reliability Subdivision is headed by a manager, who reports directly to the chief engineer of the Liquid Rocket Division of Rocketdyne. The reliability manager is also a member of the Reliability Policy Board described earlier.

This group, with specialists in all the areas discussed in the succeeding sections, formulates basic reliability philosophy, procedures, and schedules. It assists the Reliability representative in casting these into work statements which he then monitors for satisfactory fulfillment.

Through the disciplines subsequently described, this group focuses attention on possible problem areas, and pinpoints the features that require further effort to enable the attainment of required reliability goals. When areas of deficiency are noted, the responsibility for action lies with the particular group or department responsible for the occurrence of the deficiency, such as Engineering, Manufacturing, Quality Control, Logistics, etc. The Reliability Engineering Subdivision is responsible for followup to ensure that corrective action is taken.

Procedures have been established within Rocketdyne to ensure that the Reliability Subdivision is the focal point of all reliability data. Information regarding tests in progress, failures during tests, field experience, etc. is routed accordingly for examination. These analyses serve to inform Management and all departments of progress, such as what components need action, and actual product reliability. This information and subsequent action are essential to the success of any reliability program.

A senior reliability engineer is assigned within this group to ensure that all necessary action on this specific program is accomplished as required.

Many procedures have been established at Rocketdyne to ensure product reliability. These activities have been incorporated into the Rocketdyne Operating Policies and Procedures Manual, Engineering Procedures Manual, Drafting Instruction Manual, and Quality Control Operating Procedures, etc. Such items cover a variety of subject matter, as they are company wide in scope, and are applicable to various phases of reliability such as in design, test and development, processes and specifications, manufacturing, quality control, vendors, material, safety, packaging, calibration, field service, etc.

THE RELIABILITY EDUCATION AND TRAINING PROGRAM

The scope of the program includes the skill and motivation training of all personnel affecting the reliability of the product.

The purpose of the skill training is to improve reliability through application of the latest and best-developed methods of engineering, manufacturing, quality control, and material procurement techniques. This application can only be obtained through the education of the people within these activities.

This training and education will be implemented through the Rocketdyne policy of educational aid (i.e., partial payment of tuition in local colleges and universities) and through training courses within the company.

The purpose of motivation training is to generate, within personnel, the desire to accomplish highly reliable tasks through awareness of the importance of their efforts as an integrated part of the national space endeavor. The ability of management to instill this awareness will determine, to a large extent, the final product reliability.

Reliability Analysis

A high degree of reliability of the LEM propulsion system is required to ensure the crew's safety and the success of the mission.

The development efforts are directed toward this end and are greatly enhanced by the efficient use of proved analysis techniques, which are described below. Among these techniques, the most effective is the malfunction analysis. These methods are currently employed, and the results derived from their use are continuously revised, taking into account subsequent better-defined mission requirements and improvements in hardware and procedures resulting from the development program

Malfunction Analysis

The malfunction analysis is a description of possible modes of failure of a component, subsystem or system for the purpose of focusing attention on areas where changes and/or modifications in design or configuration could result in a worthwhile gain in reliability.

The listing of possible modes of failure of the components, subsystems, and systems, and of stress conditions that might induce each mode in the anticipated environment, will provide a solid basis for analysis by design review and for investigation of ways to counteract such incidents.

In the search for areas of weakness, the analyst seeks answers to the following questions:

1. What are the possible modes of failure of the component?
2. What are system consequences of each mode of failure?
3. How well defined are environmental loads?
4. How sensitive is the functional output or strength of the component to variations in the level of environemmtal loads?
5. What are the margins of strength, factors of safety, and other key design considerations that have been employed?
6. What is the predicted likelihood of failure?

Expected probability of occurrence of the various modes of failure is derived from applicable experience on similar components or elements of components.

The malfunction analysis is used: (1) to provide a check on the design to focus attention on those areas most likely to fail, as well as those malfunctions that have the most serious consequences, (2) to provide a basis for designing an optimum malfunction detection system, and (3) to define anticipated modes of failure as a basis for statistical test designs and detail test objectives. In addition to the malfunction analysis, significant efforts are expended to continue to explore other reliability methods.

Reliability Comparison Studies

Through reliability systems comparison studies performed at an early stage during the development program, the designer is provided with a comprehensive evaluation of the relative reliability of alternate systems of subsystems under consideration for the desired requirements.

Component and system Redundancy Studies

The achievement of complete redundancy in subsystems or components that are in themselves complex, requires more than simple duplication of parts. Even a relatively simple component, such as a check valve, may not permit the attainment of complete redundancy by such a simple method as the addition of an extra component. Based on the failure mode analysis and the estimated probabilities of occurrence of specific modes in individual components or subsystems, mathematical models are formulated based on varying degrees of redundancy. Full consideration is given to the interrelation of failure modes in redundant systems, and these studies assist in determining which is the best and the most economical way of increasing reliability.

Manrating and Malfunction Detection Studies

Exploration of the techniques previously described are directed mainly toward the selection of the most advantageous means of developing the highest possible mission reliability, with the ultimate assurance of maintaining the safety of the crew. Reasonable compromises in mission reliability may be necessary to increase the safety of the crew; a malfunction detection system, included to limit the seriousness of the consequences of a malfunction, may decrease the mission reliability through the chance of an erroneous malfunction signal, while increasing the safety of the system. In this area, malfunction detection systems are being investigated and analyzed to reduce to a minimum the degradation of mission reliability.

Reliability Estimation

At significant development milestones, reliability estimates are computed from results of applicable component and system testing, to indicate the growth of reliability. This is done by estimating the system reliability from the individual reliabilities of the various components which constitute the system. The evaluation of the estimate is based on data from applicable testing performed during the development and acceptance test programs, adjusted to be comparable to the exposure hazard encountered during a mission, through the use of a mathematical model.

For a specific mission requirement, individual component reliability values are obtained in the form

$$R = (1-p)^{j} e^{-\lambda t} \qquad (1)$$

where

p = combined transition failure probability of a start-stop cycle

j = required number of start-stop cycles

λ = failure rate of the operating component

t = required operating time

Then for a system of components in series the system reliability is:

$$R = \prod_{i=1}^{n} (1-p_i)^j \ e \ \exp -\sum_{i=1}^{n} \lambda_i \ t_i \qquad (2)$$

where

j = the number of required actuations of the ith component, and

n = the number of components in the system.

The use of Eq. 1 to determine component reliability is as follows: All the malfunction data derived from engine testing are reviewed, and the failure effects are analyzed. The malfunctions that affect engine operation in such a way as to cause a mission failure are considered critical failures, and are categorized into three classes:

1. Start-stop Cycle Phase. Critical failures that occur during start or shutdown phases are placed in this class, e.g., propellant valve failure to open at start, or slow in closing at shutdown.
2. Engine System Firing Phase. This class includes the critical failures that occur during engine system firing, e.g., thrust chamber jacket burn through during the run.
3. System Pressurized Phase. Critical failures that occur in a pressure-fed system when the system is under static pressure and engines are not firing are placed in this class, e.g., propellant tank flange pneumatic leakage when system is in pressurized state between firings.

The test data from engine firings are used to find the number of test exposures for components, component accumulated firing time, and component accumulated time when the system is under static pressure. With this information and the malfunction data categorized into the three classes, the following are calculated for each component:

1. Ratio of successful start-stop operations to total number of start-stop operations (S/N, equivalent to 1-p in Eq. 1)
2. Engine firing phase Mean-Time-Between-Failure $\left(MTBF_f = \frac{1}{\lambda_f}\right)$
3. System pressurized phase Mean-Time-Between-Failure $\left(MTBF_p = \frac{1}{\lambda_p}\right)$

In addition to the above information, it is necessary to establish the mission requirements for which the engine system reliability is to be determined, viz,

1. Number of start-stop cycles (j)
2. Total firing duration (t_f)
3. Total time system in nonfiring pressurized state (t_p)

With the mission requirements defined, Eq. 1 is used to determine the individual component reliabilities.

<u>Environmental Criteria Study</u>

An environmental criteria study is prepared to ensure that all personnel associated with the design and development of environment-sensitive hardware are cognizant of the magnitudes of the various environments detrimental to performance and reliability. This criteria study presents a single coordinated summary of the environmental condition and intensities that an engine system will be exposed to during transportation, storage, and operation. This document serves as a guide during design, development, and testing.

An important initial step in design formulation is the determination and specification of the environmental conditions to which each component will be subjected. This information is later verified, where possible, by system and subsystem testing, and provides a basis for environmental testing and qualification.

The environmental criteria study first determines the typical life cycle of each component. This includes such operations as checkout, assembly, transportation, acceptance test, missile assembly, launch, and firing. Each operation involves exposure to varying degrees of environment. The conditions relating to a specific component may be quite different from those ambient to the whole engine; for example, a component located near a heat source or sink will experience temperature conditions that may differ considerably from the ambient.

Environments considered in the analysis include the conditions of pressure altitude (including vacuum conditions) and associated problems of corona discharge or arc-over in electrical components, zero gravity, vibration, endurance, radiation, ignition proof, radio interference, and temperature encountered in engine operation and shock, corrosion, fungus, humidity, and sand and dust usually encountered in storage, transportation, and handling.

Levels of these environments expected to be encountered in storage, transportation, and operation are determined. Based on these values, levels are recommended for R&D test and qualification tests. This information is distributed to design and development engineers to provide a basis for formulation of the design and planning of the development test program.

Tests on the subsystem and system levels are instrumented to verify environmental conditions created by the system. The criteria are then revised to more realistically represent the actual component environments.

HUMAN FACTORS ENGINEERING

Lunar Excursion Module engine systems must be capable of being fabricated, handled, tested, installed, maintained, and used without degradation of inherent design reliability, and without incurring hazards relative to their final operational employment. It is particularly important to forestall degradation of systems reliability by human error variability, when complete and fully operational systems are to be required on compressed time schedules. A preventive reliability program in the human factors area serves to minimize human error through assurance of appropriate equipment design and the use of effective procedures. This effort includes activities related to design, development, manufacturing, inspection, and maintenance of the system, as well as development testing, operational demonstration, transport, and operational use.

Human Error Investigation

A significant proportion of the causes of test malfunctions or delays and component failures or difficulties are directly attributable to human error.

A Reliability human-factors engineer is assigned the responsibility for monitoring the failure reporting system, and reviewing all reports that are directly or indirectly attributable to human error. Surveillance is maintained over human error reported through various reliability test, demonstration, qualification, production monitoring, and field data reporting programs. The engineer is responsive to other reports from project engineers and test personnel regarding human-initiated firing stoppages, damage, malfunction, or difficulties associated with the servicing, inspection, handling, operation, or maintenance of the engine system and its related ground support equipment and facility interfaces. He personally observes the operation and handling of the engine system and associated equipment in various locations, to help find all possible sources of human error or difficulty. The analyses of the causes of such difficulties are oriented toward finding suitable corrective action, namely, design or procedural improvements, which will help to prevent the recurrence of this type of potential difficulty.

Human Engineering Surveillance

The design of all man/machine interfaces should be in accordance with generally accepted human engineering design principles and practices. These design criteria provide for maximum simplicity and ease of handling, servicing, and operation. An attempt is made to ensure that the design prevents, or is maximally resistant to, the sources of human error anticipated in the operational environment. An attempt is made to minimize and simplify the maintenance, storage, and handling procedures. Careful attention is paid to the procedures for the diagnosis, confirmation, and replacement of possible malfunctions.

Potential personnel hazards are reduced or eliminated through the use of design features that minimize the possibility of accidents. Consideration is given to those interface areas of design between Rocketdyne and other contractors, which have implications relating to personnel skill and training requirements, job aids and manuals and test and evaluation procedures.

Emphasis is placed upon the system integration, relative to human factors, of the engine system and its associated equipment in assembly, test facilities, and the vehicle. The implications relative to training requirements and training equipment, manuals of operating and maintenance instructions, and the evaluation of on-the-job skill or proficiency factors are carefully considered. Rocketdyne also conducts human engineering evaluations to verify the adequacy of human task performance, safety, and human reaction to the system, relative to the operational hardware in the operational configuration and working environment.

System Test and Evaluation

Despite careful design and component development tests, it has become increasingly obvious that, in the development of complex systems, independent or collaborative operational systems, tests, and evaluation procedures are vital to the attainment of maximum systems effectiveness or operational capability. Special systematic operability tests are conducted to ensure and verify the suitability of human factors provisions, the engine/AGE/personnel compatibility, and the correctness, clarity, and adequacy of procedural instructions. Equally important is the necessity for system re-evaluation tests, to ensure the suitability of modification kits, procedural changes, and changes of parts, materials, or sources of supply. The objective of this effort is, therefore, the evaluation of the operational effectiveness of the propulsion system under operational criteria.

The operability verification tests are conducted under the technical cognizance of reliability/human-engineering personnel, and in close collaboration with the responsible engine systems, ground support equipment, maintenance analysis, and handbooks or procedures groups. These tests are conducted by a special test team to verify the ease of operation, servicing, handling, and maintenance of Rocketdyne equipment.

Reliability Motivation

In the implementation of the reliability training program, the services of human-factors consultants are available to analyze the requirements and outline a program for constructive training. Human factors will also be considered in providing reliability communication and information in a manner that ensures greater retention and utilization of practical experience and the benefits of the training.

The use of special motivational training techniques, such as audio-visual devices, are employed in certain critical areas. This is done on a limited basis, following careful study of the actual need and optimum programming techniques that should be employed. Review of proposed motivational training aids or programs is made by a qualified psychologist from the Reliability Human-Engineering staff.

Personnel Subsystem Analysis

Technical guidance is provided to the personnel responsible for personnel subsystem basic data development below the level of the systems analysis function, including development of the Systems Functional Flow Diagrams, QQPRI, Task Index with time line, Position-Equipment Task Summary, Training Requirements, Training Equipment Justification, Technical Manual Requirements, and the basic field requirements for the collection and validation of PSS data. A human-engineering review is provided for, as required, on all personnel subsystem data and documentation.

MAINTAINABILITY

Maintainability for the Lunar Excursion Module is defined as those design features that make it possible to perform the required maintenance in space to meet mission reliability and safety objectives, and to perform the necessary ground maintenance with the minimum expenditure of effort.

Maintenance is defined as an accumulation of all the actions necessary to make ready for use, maintain, and restore the LEM propulsion system to an operating condition.

The Rocketdyne LEM maintainability program consists of:

1. Defining maintainability objectives
2. Designing for maintainability
3. Predicting maintainability design characteristics
4. Reviewing and evaluating maintainability features.

Maintainability Objectives

Maintainability features must be considered in the design together with performance, reliability, cost, etc. Subsystem and component maintainability objectives are prepared in the form of design checklists to provide the design engineer with basic maintainability guidelines.

Design for Maintainability

Maintainability as a design parameter is taken into consideration in all design decisions. Maintenance time and material resources such as spares, tools, and expendables, constitute the measure of maintainability for a given design or design approach. Maintainability, performance, and reliability are considered together in achieving good design.

The following maintainability principles are used as guidelines during the design of the vehicle propulsion system:

1. Design to minimize the complexity of maintenance by maximum use of simple design, which eliminates or decreases the requirement for maintenance.
2. Design for positive recognition of equipment malfunction or marginal performance and positive identification of replaceable parts.
3. Design to require a minimum number of tools, test equipment, and spare parts.
4. Design for optimum accessibility.
5. Design so that the mean time to accomplish maintenance work is sufficiently low to ensure mission success.

Maintainability Predictions

Maintenance task analysis is the analytical tool utilized to predict the maintainability characteristics being incorporated into the design. Subsystem and component designs are analyzed in detail to determine all possible tasks, the number of personnel required, the work location, and the tools and expendables required for each maintenance action. Maintainability predictions are accomplished concurrent with design progress, and permit analytical evaluation of the design at a time when maintenance requirements may most easily be incorporated.

Maintainability Review and Evaluation

The established Rocketdyne design review function includes a formal examination of all designs for maintainability characteristics, to ensure adequate considerations to the principles outlined above.

Maintainability features are evaluated during the normal course of propulsion system development and acceptance testing by collection and evaluation of maintainability data. Human Factors representatives critically examine the engine, support equipment, manuals, personnel, and the complex to ensure good performance of the integrated system.

VALUE ENGINEERING

Rocketdyne maintains a comprehensive Value Engineering program as a regular part of its efforts to ensure maximum effectiveness in contract performance. Consequently, cost estimates for this proposal are based on the anticipation of normal improvements and cost savings due to Value Engineering effort.

Value Engineering Staff

A full-time Value Engineering staff reports directly to the manager of the Reliability Engineering Subdivision. Staff members are qualified specialists, chosen for their broad backgrounds in design, production, procurement, and quality control. All have received special training, and are experienced in Value Engineering staff activities. The staff is responsible for directing and assisting in the performance of Value Engineering program activities. In addition to the central staff, two other Value Analysis groups are operational in the Manufacturing Services Organization and in the Material Division Cost Reduction Group. Manufacturing Services reviews tooling and planning concepts for internal cost control, and the Cost Reduction Group is responsible for motivating suppliers to assist in the cost reduction analysis of supplier designs and processes.

Motivation

A continuous program of general education is conducted to impress program personnel with the need for value engineering, the techniques used, and the results that can be accomplished. These themes are maintained through staff newsletters and reference publications, by means of posters, exhibits, product and process displays, by brochures, briefings and demonstrations directed to special groups, and by generally available staff consultation and assistance.

Specialized Training

A regular training program in the detailed understanding and use of value engineering techniques is conducted for key program personnel in all departments. The training is accomplished by means of a 36-hour seminar, during which trainees receive 16 hours of instruction in the organized system of techniques known as the Value Engineering Work Plan. This plan is essentially a six-step problem-solving procedure incorporating the best available techniques for planning the problem-solving effort, promoting thorough understanding of the problem situation, guiding precise definition of the subproblems, concentrating effort where it is most effective, stimulating creative thinking, assessing thorough cost-oriented evaluation of alternate solutions, and facilitating approval and execution of recommendations. An additional 20 hours are spent in practical team application of the approach by studies of current hardware designs. Sound recommendations arising from the studies are incorporated into the actual design and production processes.

<u>Value Study Teams</u>

The primary objective of the Value Engineering effort is to eliminate all unnecessary program costs, while maintaining the functional performance and reliability required of the end item. Key tool in accomplishing this objective is the Value Study Task Team. A sufficient number of task teams are organized to maintain the planned level of Value Engineering effort. Team members are designated by the responsible design and production groups, and a staff value engineer is assigned to each team. During component design, the teams conduct comprehensive analyses of the concepts embodied in the designs, leading to recommendations for changes in the design approach, and for establishment of plans and concepts of tooling, procurement, fabrication, and quality control. Specifications, environmental parameters, performance criteria, maintenance requirements, tolerances, and finishes are examined and questioned, to ensure maximum simplification consistent with the necessary functions of the component. Studies are coordinated with Reliability Design Review schedules, so that recommendations may be incorporated for Design Review Board consideration.

Documentation

Recommendations resulting from value study action are presented in a written report addressed to those responsible for the affected effort. The report consists of a summary of the study effort, and a description of the recommended changes, estimates of cost, and weight or reliability improvements.

Files of these reports are maintained by the Value Engineering staff, and systematically checked to determine action taken on the recommendations. Study activities and adopted recommendations are described in contractually required reports.

PRODUCTION DESIGN

Hardware Protection System

The objective of the hardware protection system is to provide primary physical and auxiliary chemical protection to the Lunar Excursion Module propulsion system and supporting hardware throughout the entire hardware life cycle, from raw materials to customer usage and/or storage. This is accomplished by the application of protective devices such as closures, enclosures, supports, containers, and supplemental environmental control systems.

At the same time that materials, processes, design, and systems problems are being evaluated and solved, the protective system for packaging, handling, transportation and storage is analyzed relative to the prevention of reliability degradation during all functional phases. The general concept and performance requirements for the over-all protective system for the engine subsystems, and major components are defined and documented.

An analysis is made of all conditions, starting with the details of manufacture and ending with the complete Lunar Excursion Module propulsion system, encompassing twelve major areas: shipment to Rocketdyne, Rocketdyne receiving, inplant handling, inplant storage, interplant movement, customer shipment, customer receiving, and customer handling, customer storage, customer usage, and organizational inter-relationship of the above areas. A program is maintained to improve the motivation and skills of personnel handling the hardware during the many phases involved.

Drawing Review

The reliability checking activity checks engineering drawings, equipment specifications, Engineering Orders, Specification Control drawings and related engineering data for conformity to established manufacturing and engineering practices, and for practicability and completeness of thought and presentation.

The checking activity calculates the fit, feasibility of manufacture, and in many cases, the function of a design. It ensures freedom from interference and an awareness of the possible use of standard parts and production engineering techniques.

SPECIFICATION AND STANDARDS REVIEW

The specification activity assists in the preparation and release of new and changed material, process, and equipment specifications found necessary to support changed engineering and ground support fabrication and/or test procedures and clarification.

The standards activity maintains company and government standards, drawings, and specifications used for all component fabrication. Changes in these items are coordinated with design units throughout the contract activity. It also assists design engineering in evaluating failures of commercial and standard parts.

Production Design Analysis

The prime function of the production design analysis activity is to assist the design engineer in the evaluation and design of rocket engine components from the standpoint of simplification, producibility, and optimum fabrication techniques. Production design analysis provides the design engineer with specialty information concerning such areas as conventional and numerically controlled machining, allied metal-removal methods such as ultrasonic, chem-milling, electrical discharge, etc., thread rolling, gear forming, splines, etc., sheet-metal fabrication operations such as spinning, hydro-forming, shearing, punching, etc., forging, casting, and extrusion processes, tube-forming welding fabrication, spring design, and cost analysis.

DESIGN REVIEW

An existing, independent audit team within the Reliability Engineering Subdivision, composed of senior-level engineers, and supported by various technical specialists, evaluate the design and development processes to ensure that the best design disciplines and practices are followed, to determine that all applicable past experience is considered, and to focus attention on all areas where operational reliability of the engine systems might be adversely affected. The scope of activity of this team starts with the basic schematic drawing, and is carried down through lower-level drawings as required. Attainment of the highest possible hardware reliability is dependent on its ability to be manufactured, serviced, and inspected. These factors are considered essential elements to be evaluated in the course of the design review program.

The program summarized above and outlined in additional detail in the following paragraphs is in actual use at Rocketdyne on present programs, and has proved to be workable and highly effective. The space engine system design review function uses the same nucleus of personnel to provide the required design review coverage.

Three stages of the design review generally are performed on all new designs. These are designated as preliminary, critical, and final. Special reviews are also conducted on modified designs. Purchased items are similarly subjected to design review.

The preliminary design review is held early in the design phase to evaluate the basic concept or design approach against the performance and environmental requirements. Engineering analyses, preliminary sketches, schematics, layouts, and preliminary check lists are used. Simplicity of design and the use of standard, proved design concepts are stressed. Functional and environmental parameters are reviewed for accuracy and assurance that design margins for stress, pressure rates, leakage, and other performance characteristics are adequate to meet specified requirements under all usage conditions. Engineering data are reviewed to assure that thorough static and dynamic analyses have been performed. Inherent material or stress problems are recognized, and action is assigned for test and resolution early in the design phase.

The critical review is held on completion of the formal layout, just prior to the start of detailing. The layout, check lists, complete static and dynamic analyses, malfunction studies, material and stress work, and any component evaluation test work are reviewed to ensure that nothing has been overlooked that could impair the reliable performance of the resulting hardware. The effects of part tolerances, fluid dynamics, and fatigue due to vibration or environmental extremes are evaluated. Human factors considerations are evaluated to avoid design conditions which may lead to improper assembly, handling, storage, or installation. The malfunction analysis is reviewed in detail to ensure that a thorough evaluation of all failure modes and causes was made, that time of occurrence was considered, and that everything possible was done to render failure less probable and less critical through redesign, derating, redundancy, or other methods.

Upon completion of development tests, the final review is held prior to the release of deliverable hardware. All drawings, process specifications, test reports, check lists and prototype hardware are reviewed to ensure that complete implementation of previous review action items has been made, that drawings and process specifications exercise adequate direction and control of parts fabrication, handling and functional check, and that development test results reflect achievement of all design goals. Tooling, manufacturing processes, cleaning, handling, packaging and storage methods are investigated. Quality control measures are evaluated, and acceptance and checkout tests are reviewed to determine that future reliable performance can be ensured. Handbooks and bulletins, if included in the program, are evaluated to ensure that adequate service, installation, and removal practices are defined.

Whenever new requirements or development test problems arise that indicate the need for design changes, special reviews are held to evaluate the cause and the proposed solutions. Special reviews are also used to evaluate critical design areas in general application, such as flange seals, brazed joints, etc., and for specific component problems too complex or time-consuming to be covered in the general reviews.

STATISTICAL TEST DESIGN

The attainment of high levels of reliability requires careful attention to all details of product planning, design, and development. To achieve these levels economically requires efficient utilization of test time and test hardware. Statistical test design satisfies both of these requirements for test programs of all types. The program efficiency achieved with statistical methods exceeds that avilable with intuitive, nonstatistical procedures.

When used in support of sound engineering judgment, the methods of statistical test design offer many advantages to a development program. Notable among these are the completeness with which test objectives are developed, and the increased accuracy of the resultant conclusions. Because of the efficiency of these methods, greater quantities of usable data are acquired, and the total effort to achieve specified development and reliability goals tends to be reduced. A measure of the relative importance of variables being investigated is obtained, allowing effort to be concentrated on those variables having greatest influence on the system. In addition to obtaining an estimate of the basic parameters, statistically designed tests provide a means for estimating experimental error, thus allowing a better understanding of the operating characteristics of the test process. Finally, when confidence levels are established, it may be possible to determine the number of tests needed to attain a given objective. Taken in its entirety, statistical test design offers a comprehensive method for formalizing a test program.

Over a period of many years, Rocketdyne has used statistical test design in numerous liquid-propellant rocket engine investigations. Designs for the study of performance characteristics of components and systems, the evaluation of processes, and the selection of optimum hardware designs are but a few of the many designs that have been developed. This background of experience is brought to bear in the preparation of test programs for the Lunar Excursion Module propulsion systems.

There are several standard statistical designs suitable for rocket engine system and component testing. Some of these are the factorial design, the rotatable design, the composite rotatable design, and the sensitivity experiment. Analytical techniques available for processing data required in a statistically designed test program are the analysis of variance, regression analysis, multivariate analysis, discriminant analysis, and sensitivity analysis. For most test programs, one of the standard designs is used. However, in those instances when a unique test problem arises, Rocketdyne develops a statistical design from fundamental concepts. By tailoring a design to specific test requirements, maximum advantage is taken of the techniques of statistical test design.

Program costs and schedules are directly related to the number of tests performed. With an efficient statistical test design, testing to achieve specified goals tends to be reduced. Statistical test planning is an integral part of Rocketdyne's reliability program. It offers a comprehensive method for critically analyzing development and reliability objectives. At present there appears to be no better method for formalizing a test program.

An example of the application of the principles of statistical test design to the development of a rocket engine is given below, and a table is presented to facilitate the selection of a test plan for comparing injector designs for the purpose of determining the best performing injector. The test plan is based on performing a given number of tests on each of several injector designs at nominal conditions. The comparison uses specific impulse as the measure of performance. This approach is based on the assumption that an injector that performs best at the nominal point performs best anywhere within the range of required operation. The test plan for analyzing injector differences is based on the use of the T-method of multiple comparison.

TAB|

LUNAR EXCURSION MODULE PROPUL|

k	n	$\beta = 0.01$				$\beta =$	
		$\alpha = 0.05$	$\alpha = 0.10$	$\alpha = 0.20$	$\alpha = 0.50$	$\alpha = 0.05$	$\alpha = 0.10$
4	4	5.71	5.26	4.77	4.01	5.02	4.57
	5	4.91	4.54	4.13	3.48	4.34	3.97
	6	4.37	4.06	3.70	3.12	3.89	3.57
	7	3.99	3.70	3.39	2.86	3.55	3.27
5	4	5.76	5.34	4.88	4.14	5.12	4.69
	5	4.99	4.64	4.25	3.62	4.45	4.10
	6	4.47	4.16	3.82	3.26	4.00	3.69
6	4	5.80	5.40	4.97	4.25	5.19	4.79
	5	5.05	4.75	4.35	3.74	4.53	4.24

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).20	α = 0.50
7	3.01
1	2.65
3	2.40
[illegible]	2.21
[illegible]	3.20
[illegible]	2.83
5	2.57
[illegible]	3.35
3	2.97

FOLDOUT FRAME 2

E 1

SION SYSTEM STATISTICAL TEST DESIGN

= 0.05		β = 0.10		
α = 0.20	α = 0.50	α = 0.05	α = 0.10	α = (
4.08	3.32	4.71	4.25	3.7
3.57	2.92	4.08	3.71	3.3
3.22	2.64	3.65	3.34	2.9
2.95	2.42	3.34	3.06	2.7
4.23	3.50	4.82	4.40	3.9
3.72	3.09	4.20	3.85	3.4
3.36	2.80	3.77	3.46	3.1
4.35	3.64	4.90	4.50	4.0
3.83	3.22	4.28	3.99	3.5

RELIABILITY ASSURANCE

The primary goal in the development of the LEM is the achievement of the maximum inherent reliability possible with the funds and time available. To obtain this reliability, new concepts must be formulated, and past and present methods of reliability measurement and demonstration must be scrutinized to determine their applicability to the LEM program.

The demonstration of high reliabilities to levels of high statistical confidence is extremely difficult, costly, and time consuming. The number of tests required to statistically demonstrate even 99.5 percent reliability to 90 percent confidence is 460 with no failures occurring. To run these tests solely for demonstration purposes is considered an inefficient expenditure of effort, when that same effort could be applied to further development of the system. To achieve the maximum reliability with a minimum of time and money, the following program is proposed.

In view of the concept that reliability begins with and is inherent in the basic design of an engine, maximum effort is applied in this phase.

Early in the design stage, upon definition of the mission and environmental conditions, a comprehensive reliability analysis is performed including system reliability analysis, failure mode (malfunction) analysis, and redundancy and comparison studies. These analyses result in the formulation of a logical mathematical model used to determine system reliability on a component and subassembly basis. The information gained from this process provides design criteria covering all the conditions and requirements for a reliable product.

This technique, which is described in the Analysis of Variance by H. Scheffe, uses the following statistic:

$$q = \frac{\bar{x}_1 - \bar{x}_2}{s/\sqrt{n}}$$

where

$\bar{x}$ = highest average specific impulse observed for an injector

x_2 = next highest observed average specific impulse for an injector

s = pooled standard deviation of all the observed specific impulses

n = number of tests performed on each injector

This statistic compares observed performance of the two highest performing injectors to determine whether the highest observed performance is significantly higher than the performance of the other injectors. Before a specific test plan can be formulated, it is necessary to know the following:

1. k, the number of injectors being compared
2. n, the number of tests per injector
3. d, the difference between injectors, in terms of specific impulse, that is felt to represent a substantial improvement
4. β, the risk that this substantial improvement will go undetected due to sampling variation
5. α, the risk that two injectors will appear to be different, when in fact they are identical in performance capability
6. σ, the approximate test-to-test standard deviation

At the present time, these numbers are unknown. As a result, a table has been formulated to take into account the possible values that the above unknowns might assume. Table 1 presents the value of d that results from the particular combination of the aforementioned unknowns. The table is based on a σ of 0.5 percent of a minimum specific impulse (~ 315). It is not necessary to vary σ, since it is directly proportional to d. As a result, if it is found that σ is actually closer to one percent, a new table can be obtained by multiplying all the d's by two. It is felt that 30 tests would be the maximum number allocated for such a program. As a result, only test series involving 30 or fewer tests have been considered. The use of the table can best be illustrated by presenting an example. For this example, assume the following:

1. There are five injectors to be compared.
2. A risk of five percent is taken that a true difference of 3.4 seconds between injectors will go undetected.
3. A risk of 20 percent is taken that two injectors that appear to be significantly different are, in fact, equal in performance.
4. The test-to-test standard deviation is 0.5 percent.

Entering the table for $\beta = 0.05$, $\alpha = 0.20$, and $k = 5$, the value of d most closely matching the 3.4 second requirement is 3.36. This value occurs for $n = 6$. Therefore, to achieve the desired degree of protection, it will be necessary to perform 6 tests on each injector.

When the design has been completed, a progressive test program is initiated. The primary purpose of the development program is the discovery and correction of system weaknesses. At first, components are tested under nominal conditions to determine performance characteristics and general design integrity. Testing then proceeds to maximum specified conditions and overstress testing. Overstress testing is a means of accelerating the discovery of weaknesses in the system by subjecting components to conditions above those required or expected. The types of overstress tests and stress levels reached are determined through studies of the expected failure modes (from the malfunction analysis) and environmental conditions through an environmental criteria study. Modes of failure that are not forestalled by redundancy, and that would have the most serious consequences to the mission, have first priority for rigorous overstress investigations. Reduction in failure probability of these modes most materially affects over-all system reliability. A substantial effort is directed toward the thrust chamber/injector combination. Development objectives are directed, as well, to proving the concepts of redundancy employed in the design to ensure that the reliability predicted by the mathematical model can actually be realized. By subjecting a component or system to elevated stress levels, failures are induced and weaknesses are revealed more quickly. Thus, corrective action can be taken earlier in the program. The techniques of statistical test design are employed to ensure the maximum amount of information and efficient acquisition, interpretation, analysis, and use of this information, with a minimum number of tests.

When malfunctions do occur, they are evaluated to determine (1) the mode of failure, (2) the mechanics of the failure, (3) the cause of the failure, (4) whether the cause is attributable to design or manufacture, (5) the relevancy of the failure to the mission (Is it critical and can it occur during the mission? How does the environment of the test relate to the mission environment?) and (6) the best method of correcting the conditions leading to the failure. The method of correction may include strengthening the part, reducing or isolating the applied stress, making the consequences of the failure unimportant, or changing the design, i.e., employing redundancy or improving the manufacturing process. After corrective action has been taken, tests are conducted to verify the effectiveness of the correction.

This process of discovering failures, correcting them, and providing the correction is considered to be a method of ensuring the achievement of maximum reliability with the most efficient expenditure of effort.

Overstress Testing

The Reliability Assurance program relies heavily on overstress testing. As the hardware is developed to a high reliability, failures occur so infrequently that it is hard and expensive to locate potential problems. Overstress testing is a technique to disclose potential weaknesses more efficiently so that proper action may be taken for improvement. Overstress tests probe beyond normal limits of vibration, temperature, speed, stress, procedures, operation sequences, timing sequences, etc. Care and judgement must be used so that normal failure modes are accelerated without introducing new types of failure modes. Malfunction analysis is an aid in this planning to seek the weaknesses of each potential failure mode. Frequently it is found to be more efficient to do this overstress testing on components in a laboratory where such stresses can be more carefully controlled, and also can be more widely varied. (On an engine, an overstress on one component is limited by system tie-in to other component limits.) In other cases, it may be more efficient to simulate multiple environments on the system level.

RELIABILITY EVALUATION TESTS

To further aid in the development of reliable hardware and manufacturing capability at the earliest possible data the following test programs are conducted. These test programs are performed or monitored by the Reliability Group to obtain an impartial evaluation.

During the R&D phase of the program the Reliability Test Unit evaluates the components that are considered environmentally sensitive. Components and/or systems are exposed to environments that are considered detrimental to reliability. The intensities of these environmental conditions are representative of the service conditions as specified by the environmental criteria. The major effort is placed on vibration, humidity, temperature and life-cycle tests, the environments considered most conducive to malfunction. Information gained from these tests is utilized to determine if redesign effort is required. Subsequent retesting is performed in any cases involving redesign.

This program is accomplished as a joint effort by reliability and development engineers. The possibility of oversight during the testing effort is minimized through a plan of this type.

Reliability Verification Tests

The Reliability Verification Test (RTV) program is designed to verify, through testing, measuring, and/or evaluating data from other records or previously conducted tests, that a specific manufacturer's process is capable of producing an article that will reliably satisfy all service requirements.

The RVT program applies to components and assemblies that are considered susceptible to performance failure or degradation by virtue of variation in manufacturing techniques, and for which either a failure or performance degradation would normally cause a safety hazard, or prevent achievement of a performance objective of the missile or space vehicle system, or cause undue field maintenance and/or delay in launch. The program applies to procurement from Rocketdyne plants, other North American Aviation Divisions, and/or suppliers.

RVT is performed:

1. On first available items from a source
2. Upon a significant change in process or subcontract structure
3. Upon a design change that may affect reliability

Component Qualification Tests

Prior to release of component designs for production, a formal qualification program is performed. This test program is designed to ensure that all sensitive components are capable of fulfillment of the mission requirements. The tests to be performed and test intensities selected will be mutually agreed upon by Rocketdyne and the customer.

DATA REPORTING AND ANALYSIS

One of the basic services required in support of the Lunar Excursion Module propulsion systems program is that the contractor collects, analyzes and disseminates reliability and maintainability data in the form of routine and special summaries for engineering development and customer uses. The primary medium used in the collection, processing, and preparation of such summaries is the RAPID System (Rocketdyne Automatic Processing of Integrated Data). Basic reliability data are not suitable for direct application by design, development, and manufacturing personnel, and are necessary for Reliability engineers to perform the service of converting the data into usable form. Immediately available and up-to-date reliability measurements and summaries, supported by complete data histories taken from R&D, receiving inspection, manufacturing and field operations, are prime requisites in support of a system reliability evaluation and improvement program. In general, the types of information included in the RAPID System are:

1. Component and Engine Identification Data. A comprehensive listing of critical items. For accurate and up-to-date operational history, the identification data are related to each assembly, checkout, or test operation of a specific propulsion system. Also, the frequency and type of operation are recorded for reliability evaluation and spares procurement.

2. Component Information. Data input begins with component buildup. This information includes a listing of serialized items within the component, where applicable, and what tests are performed, including the results. Any subsequent testing is recorded as it occurs on each individual component through engine buildup operations.

3. Test Description. This information details the test requirements, objectives, and results desired. This all-inclusive form can best be explained as describing the actual operations that are performed during captive testing. The information derived from this type of testing is utilized for estimating and predicting engine and component reliability.

4. Failure Data Analysis. An essential integrant of system reliability and maintainability. Failure reporting originates at the time a contract is awarded, and continues through research and development, manufacturing and field operations. The collection, analysis and feedback of failure and repair information to the proper action activity, with appropriate followup is fundamental to the accomplishment of a mature design.

The required information is submitted by departments responsible for operations in the various areas. These data are processed and stored in a central reliability data bank, from which they are selected and reproduced in the format required to meet the routine and special study needs of the originating department or the customer. In addition to easily retrievable descriptive data, this system also stores classifications of applicability for reliability evaluation, and of success and failures of applicable tests. This applicability classification permits a calculation of reliability to be made on a particular component or group of components at any stage of development. The system described above is a comprehensive data collection procedure with all divisions within Rocketdyne participating.

Engineering, Field Engineering, and Quality Control are the basic sources of data, and each division is a recipient of data from the other. Engineering provides records of engine and component experience during the research and development programs. Quality Control provides records about vendors, Receiving Inspection, manufacturing and acceptance testing operations. Field Engineering provides records of all field operations. Procedures have been adopted that ensure the feedback of data to the proper departments within Rocketdyne, and the Reliability Subdivision has been assigned the over-all control and responsibility for this system.

Rocketdyne maintains a complete data collection system that will collect, evaluate, and process all reliability and maintainability data on individual components and engine systems during the complete Lunar Excursion Module propulsion system program. This includes all identification part number and serial number data, operations, repairs, failures, analyses, and corrective actions, and from this the Reliability Group continually monitors reliability growth and product improvement.

FAILURE ANALYSIS AND CONTROL

Input

The usual class of problem requiring failure analysis is that of hardware weakness revealed by laboratory, component, or system test and reported through the RAPID failure reporting system. This includes engineering R&D tests, Quality Control acceptance tests, and reports from field usage by Logistics.

Failure Recurrence Control. The obvious direct causes are corrected, the drawing changed, inspection tightened, etc. When a direct cause cannot be assigned as the certain cause, logical improvements are made. To prevent recurrence of the problem, such failure modes are considered in future designs, and assured by check lists in design review.

Frequently a more basic cause exists that permits the direct causes to occur. Basic causes are corrected by providing better information, training, motivation, management procedural controls, etc. so that experience is retained and in such a form that it is available to all who can use it.

Other areas involving maintenance, manuals, specifications, procedures, processes, human factors, etc., are examined for improvements.

Analysis

Failed hardware is critically tested, dissected, and examined by design and laboratory specialists. The Reliability Group assists in a systematic evaluation of the problem area, looking for correlation with previous component and system experience.

Followup

The Reliability Group first ensures that the line group responsible for the analysis has all available information, hardware, etc., ensures coordination of various groups if several are involved, and follows up to see that action continues until conclusions have been reached.

Basic Cause

Analyses tend to stop when a direct cause of the failure is ascertained. Basic causes (such as lack of information, training, or proper procedural controls) remain uncorrected and thus permit recurrence of similar problems. The Reliability Group makes special efforts to probe for these basic causes.

QUALITY ASSURANCE ORGANIZATION

MANAGEMENT STRUCTURE

Quality assurance at Rocketdyne is administered by the Director of Quality and Reliability, who has the general responsibility for developing, monitoring, and evaluating the quality control policies and operations of all Rocketdyne activities. Specific functions of the Director include the study, analysis, and interpretation of operating data to provide division and corporate management with significant reports on quality control activities; investigation and recommendation of new methods, techniques, and equipment for quality control operations; coordination and assistance in the development of uniform quality requirements; and review of quality policies, concepts, and trends with customers through liaison with customer quality control offices. In addition, the Director of Quality and Reliability is Chairman of the Rocketdyne Reliability Policy Board, responsible for establishing reliability policy and guiding programs for maintaining or improving the reliability of Rocketdyne products.

The Director of Quality and Reliability reports directly to the Director of Administration and Engineering Operations (Fig. 2). Because of this direct line of communication, effective implementation, as well as problem-solving, at a high level can be accomplished without the need of middle-management approval and subsequent delay.

This concept of direct communication is followed throughout the Quality Assurance organization (Fig. 3). Each major product operation is represented by a Quality Assurance Manager to provide guidance and coordination of quality assurance operations. Each of these managers

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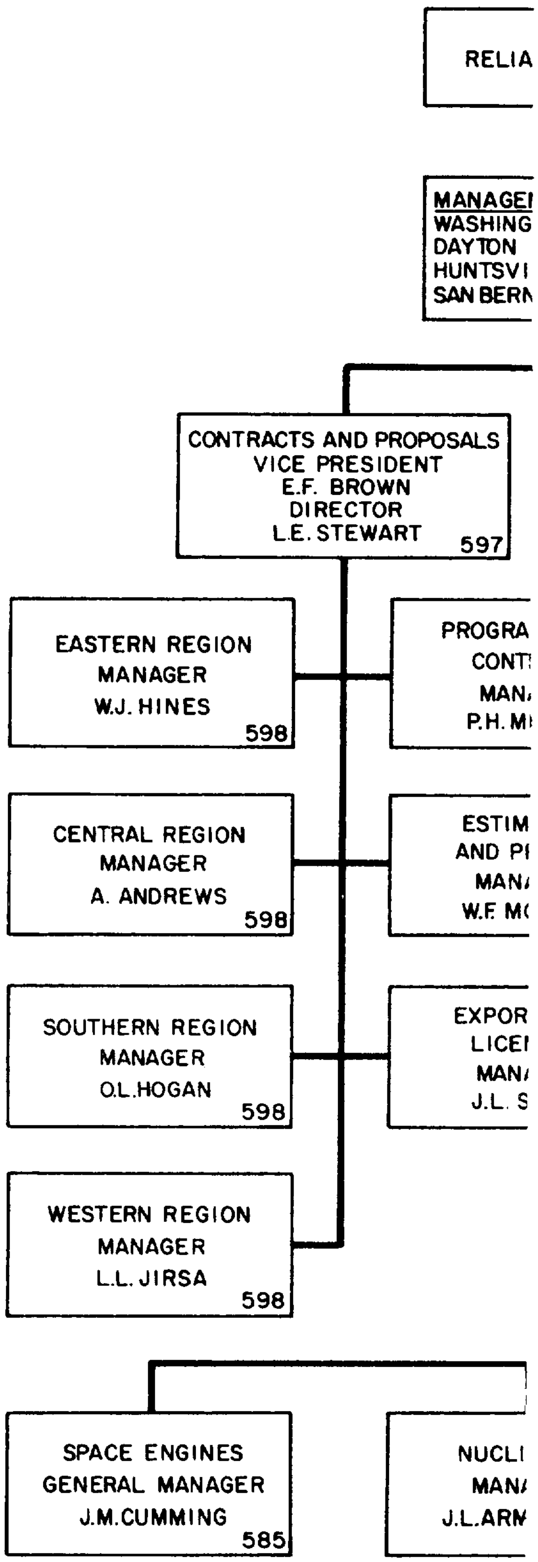

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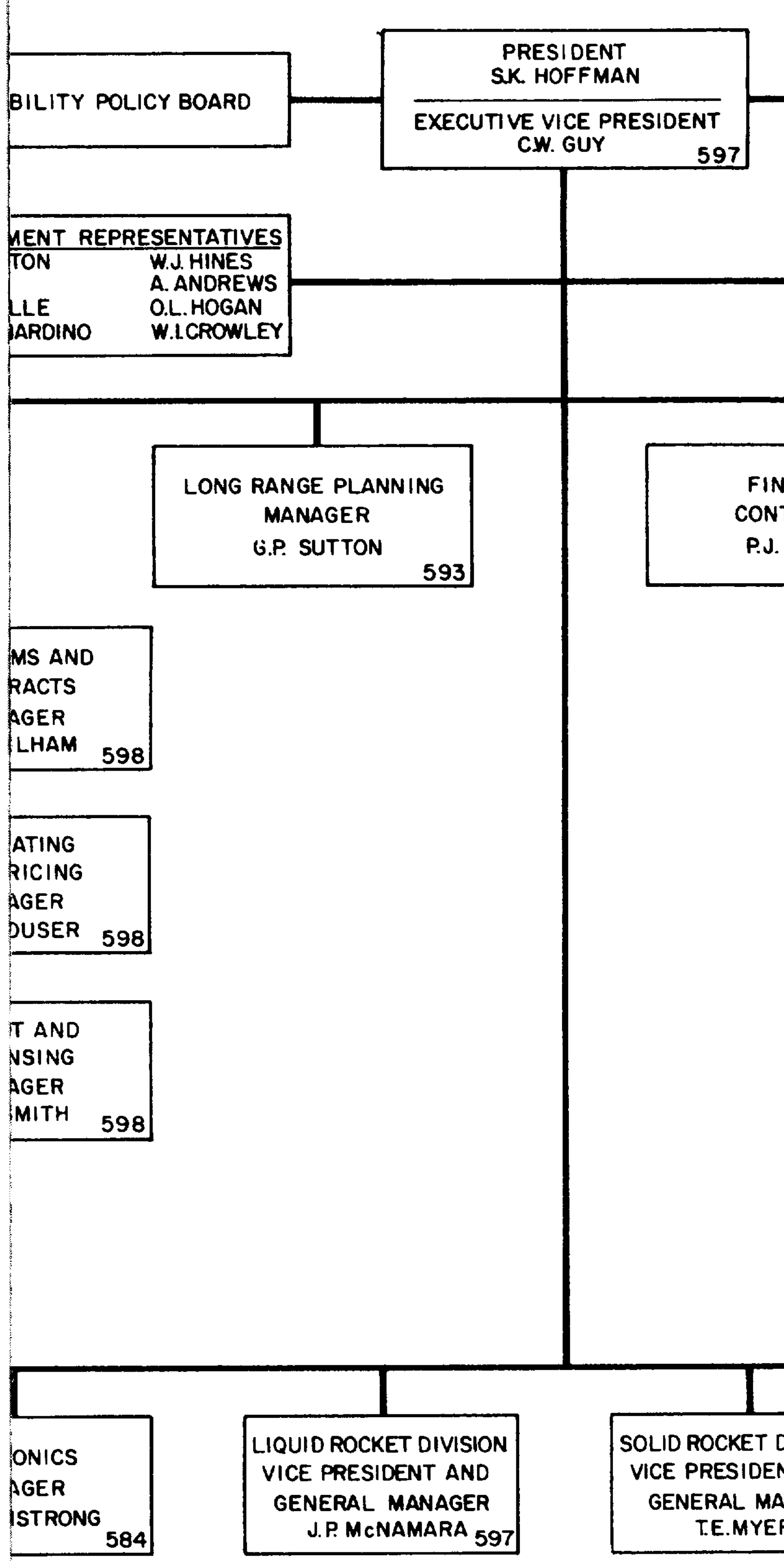

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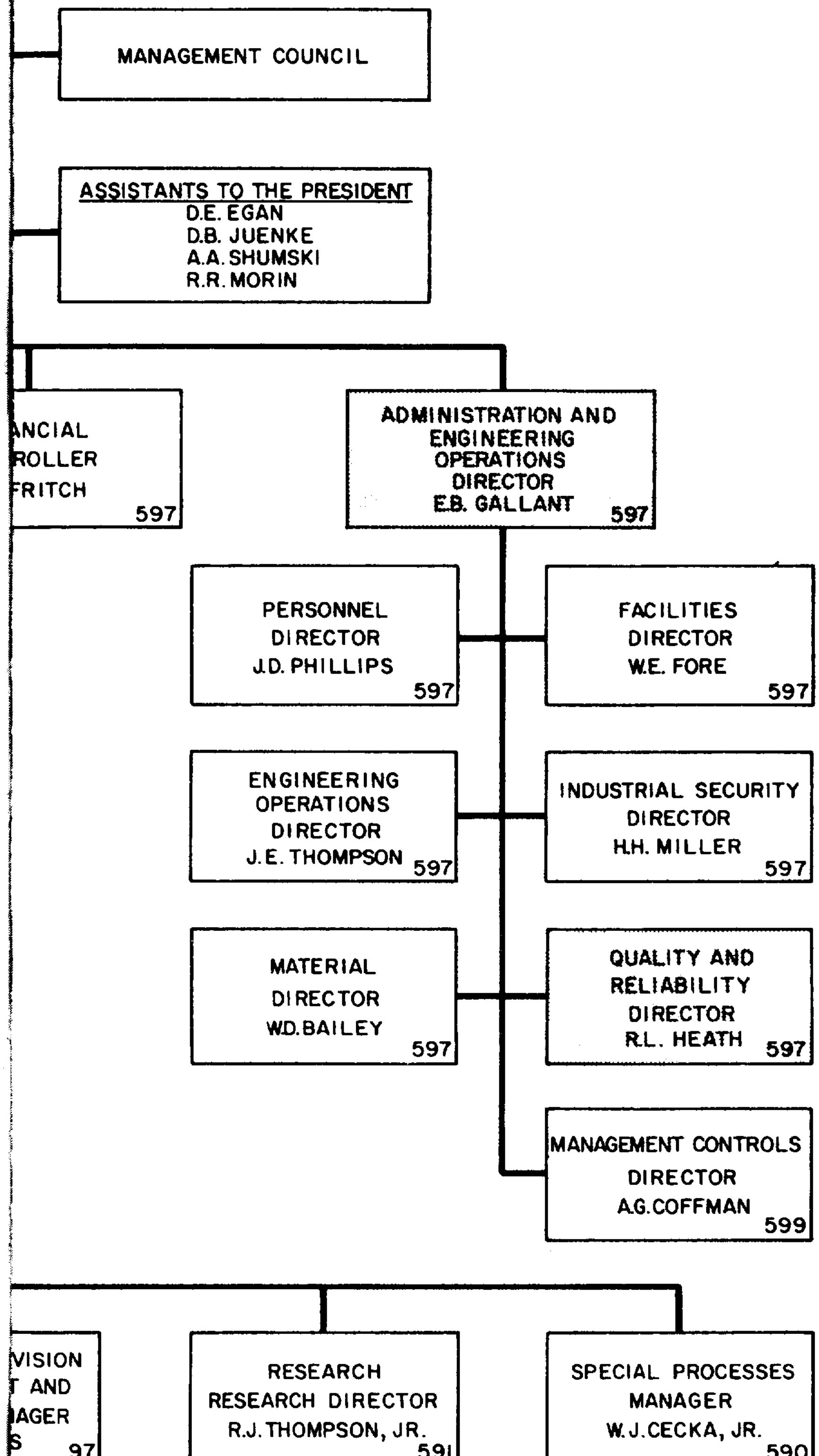

Figure 2. Rocketdyne Management Organization

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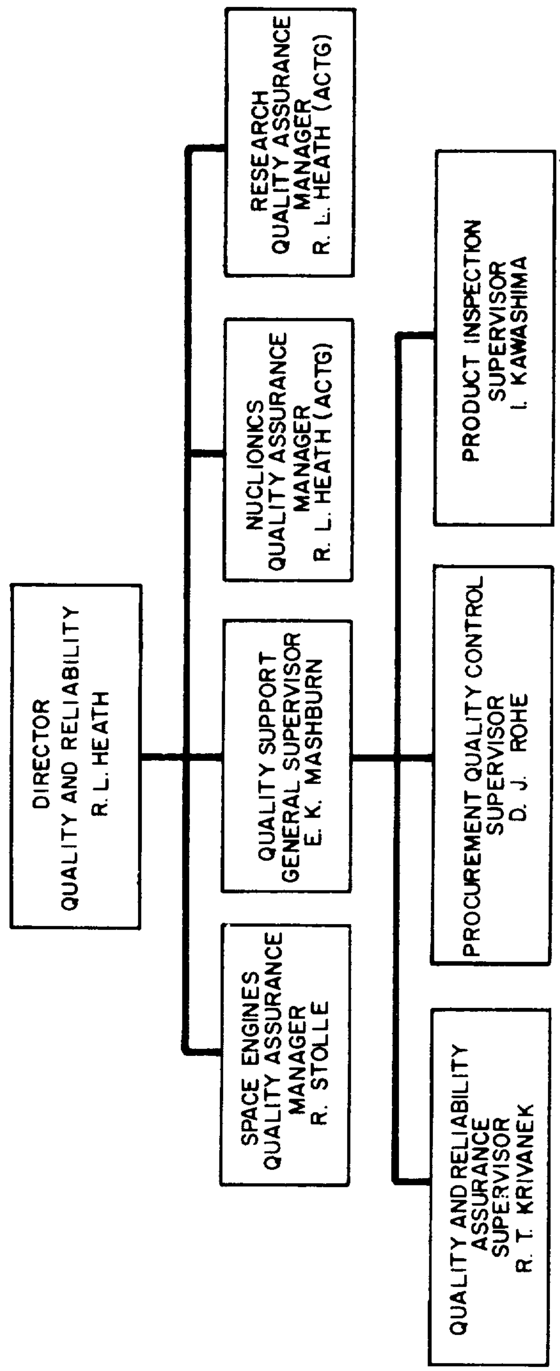

Figure 3. Quality Assurance Management Organization

in turn, serves in a position of line authority for his particular operation from which he can effectively direct and monitor quality assurance functions (Fig. 4).

Similarly, each of the operating units of Quality and Reliability is provided with a direct line of authority between unit supervision and the division director. Thus, the effectiveness of the quality program functions and the ability of quality assurance personnel to assess, document, and report true quality findings is not compromised by considerations of other duties. In addition, the freedom of communication between all levels of the quality assurance organization allows management to be continuously aware of the needs and problems of the operating units.

OPERATING STRUCTURE

Functional responsibilities for operation of the Rocketdyne quality and reliability program are shown in Fig. 5. As indicated, each of the operating units performs a discrete phase of the program for all Rocketdyne product operations. This organizational structure, rather than a number of project-oriented units, each performing a complete quality assurance program for its particular project, was chosen to provide flexibility and uniformity of quality applications between projects. In addition, this type of operating structure allows the total experience of the Rocketdyne quality organization to be concentrated on specific problems peculiar to any one product operation.

The Quality and Reliability Assurance Unit is responsible for planning and monitoring the quality assurance program to make certain that all objectives established during engineering design are fulfilled, and

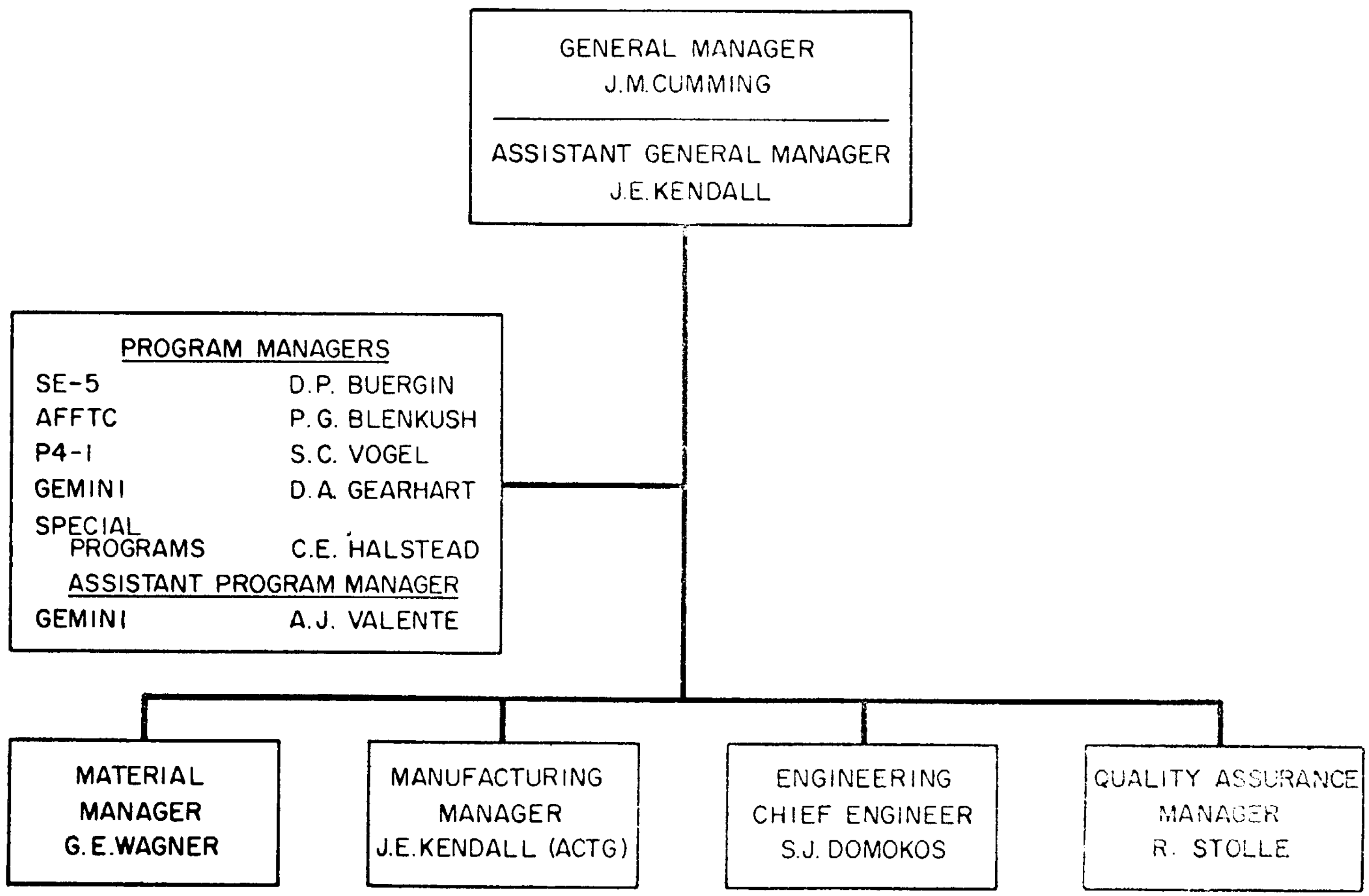

Figure 4. Space Engines Management Organization

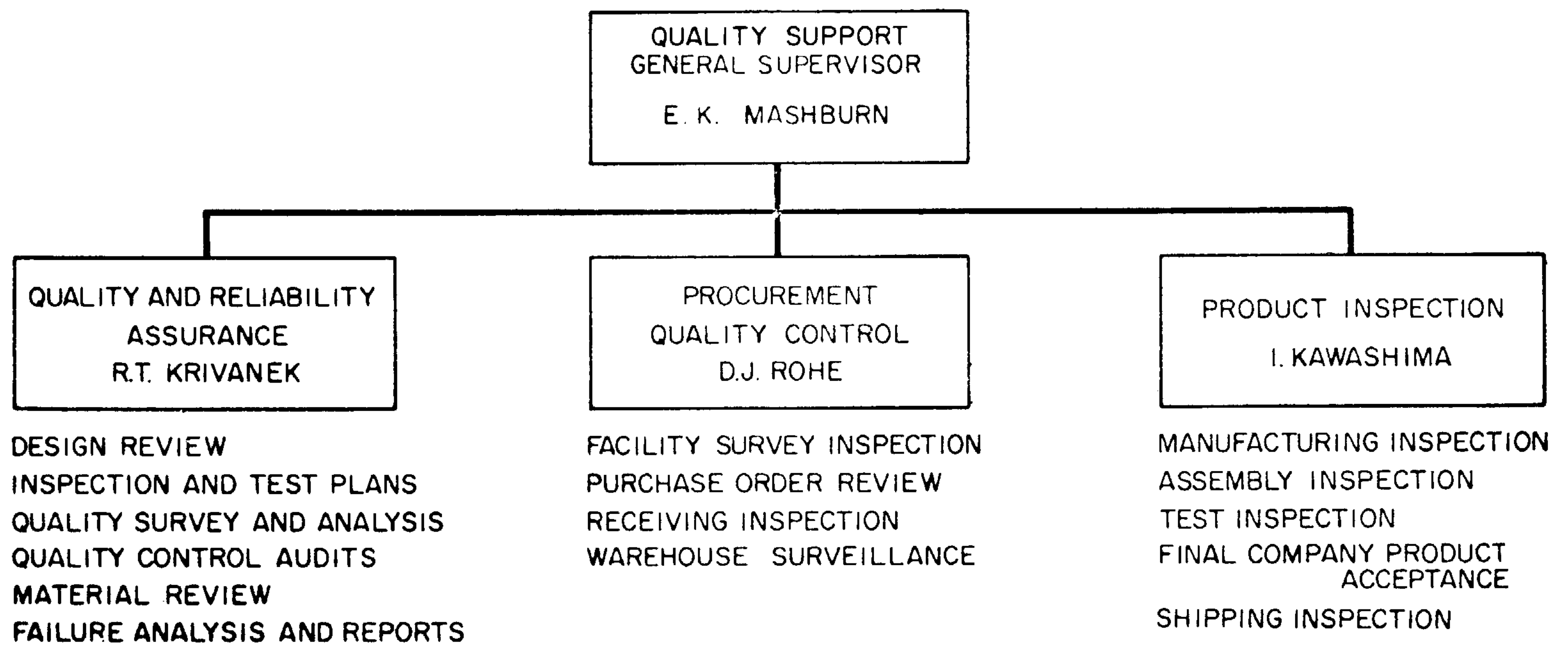

Figure 5. Functional Organization

that reliability goals and programmed growth established by Rocketdyne Engineering are attained. Beginning with system design, this unit initiates design reviews to make certain that realistic and attainable quality requirements are provided for deliverable Rocketdyne products. The unit formulates inspection plans, performs quality surveys and analyses, and conducts periodic audits of quality control measures to determine the effectiveness of the quality program. An additional responsibility of this unit is to conduct failure analyses and provide information feedback in the form of failure reports to the Rocketdyne organization and to the customer on modes of failure and corrective actions taken.

The Procurement Quality Control Unit maintains control over Rocketdyne supplier activities, and is responsible for the receiving inspection functions of the division. Specific duties include: (1) facility survey inspection of potential suppliers to evaluate supplier ability to deliver products consistent with Rocketdyne and customer quality standards, (2) purchase order review to ensure that the supplier is furnished all necessary information to allow him to deliver a product that meets quality requirements, (3) receiving or source inspection performance in accordance with the inspection plans developed by the Quality and Reliability Assurance Unit, and (4) warehouse surveillance to control product storage and rotation of age-dated materials.

The Product Inspection Unit is responsible for monitoring the quality of all items fabricated for customer delivery within the Rocketdyne organization. In performing this function, the unit applies the final criteria in determining Rocketdyne compliance with all quality reliability requirements of drawings, specifications, and other contract documentation. Hardware inspection is conducted at each stage of development in accordance with the established inspection plan. The inspections include physical and dimensional tolerance checks on individual components, electromechanical and functional testing of completed assemblies and systems, and inspection of the calibration of engines and major systems. In addition, complete results of these inspections are recorded to provide a quality history and data buildup of individual components as well as completed systems.

Shipping inspection of all Rocketdyne- or supplier-furnished items to the customer to ensure that all items, including spares, conform to design requirements and that all items are properly packaged in accordance with applicable packaging, preservations, and handling requirements.

Additional responsibility of this unit includes the calibration of all tooling and measuring fixtures used during the fabrication and inspection processes. Recalibration and periodic inspections are made to ensure the continued accuracy of the measuring equipment.

In the preceding paragraphs, the operating areas of the functional units have been defined. The application and interrelationships of these functions in monitoring and controlling the Rocketdyne quality assurance program will be described in detail in the following sections of this report.

DESIGN AND DEVELOPMENT CONTROL

Rocketdyne quality assurance provisions begin concurrently with product design, continue through each step of the development program, and accompany the delivered product throughout its operational life. A chart demonstrating typical product flow through the design and fabrication stages to the point of customer acceptance and delivery is shown in Fig. 6.

DESIGN REVIEW

Prior to release of a product design for fabrication, a design review is conducted to ensure adequacy of the design and completeness of product requirement definition for manufacturing purposes. The reliability engineering phase of the review is directed toward design features such as clearances, fits, previous experience with components and service environments, and mechanical and electrical properties. The quality assurance phase of the review is based on the reliability engineering decisions, and is directed toward formulating clear, complete, and unequivocal statements of product requirements for manufacturing and subsequent inspection use.

The combination of these two phases of design review is the proper antecedent for high quality and reliability of the product to be delivered to the customer.

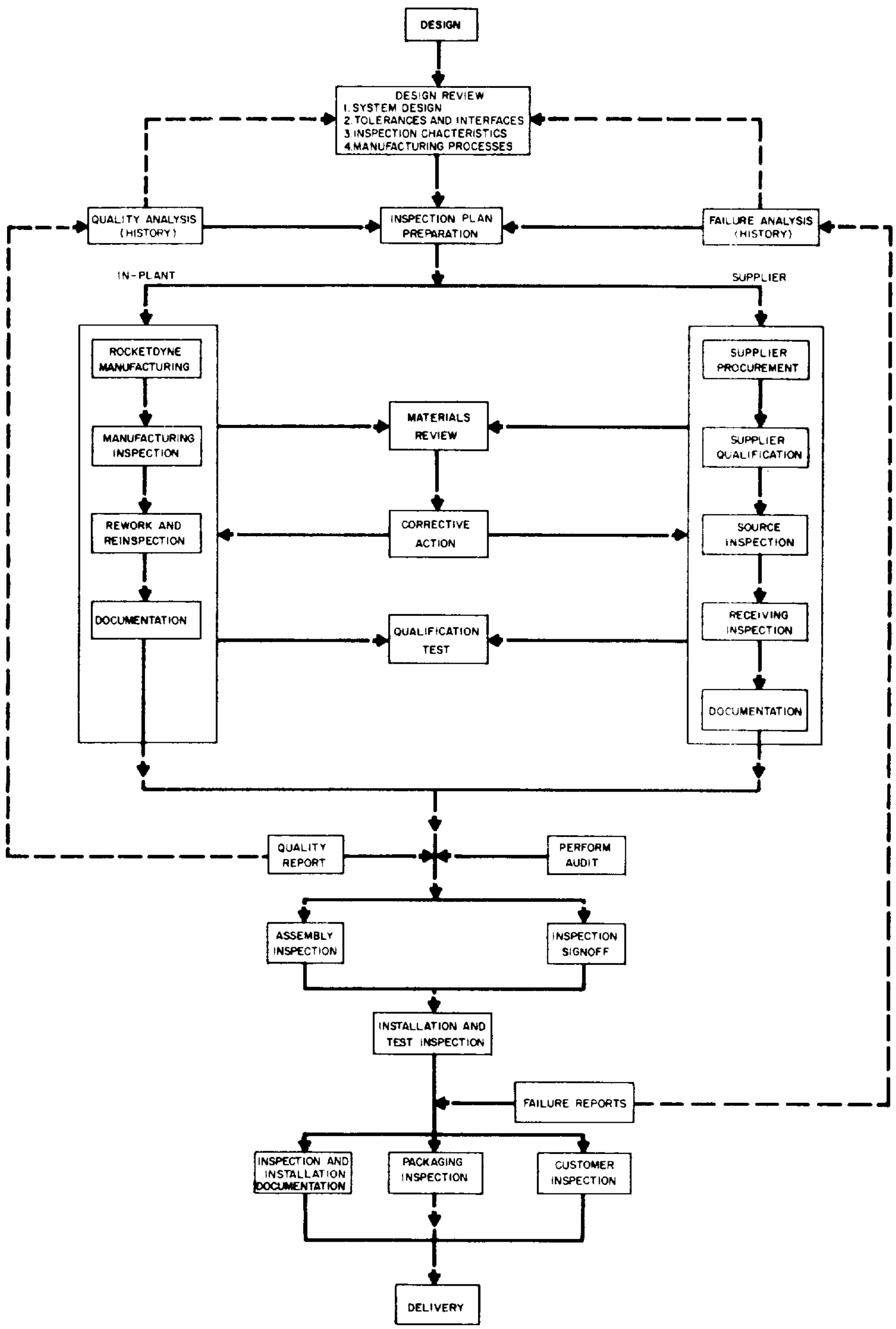

Figure 6. Quality Assurance Operational Flow Chart

Qualified and Preferred Parts

As indicated in Fig. 6, the quality and failure analysis histories of components and parts are evaluated during the design review. In addition, qualified and preferred parts lists compiled as the result of Rocketdyne experience in similar applications, and preferred parts specified by the procuring agency are used in the selection of components for specific applications.

Government-Document Review

Results of government-document reviews to determine the adequacy of product quality requirements are incorporated, as applicable, in the engineering drawings, specification, and related documents.

PLANNING

Based on the results of design review action, the product design may be released for fabrication, returned for modification, or subjected to further engineering consideration. Where quality features have been evaluated, determined to be adequate, and incorporated in the design drawings, the drawings are released for part fabrication.

Control Documentation

From the drawings, and as a result of information obtained during the design review, additional documentation required to monitor and control product quality throughout the fabrication process is prepared.

A production order is written for each detail part. This order identifies the part, lists materials to be used, operations to be performed, methods to be used in performing the operations, and points in the fabrication process at which inspections are to be made (Fig. 7). A quality control inspection plan is also prepared for each detail part. The inspection plan used to perform inspections at the points indicated on the production order, specifies details of the inspections to be performed of critical and certain major characteristics and lists applicable specifications and special equipment required to perform the inspections.

Inspection Plan. The inspection plan and any related documentation, which may include a test plan and an assembly detail record, constitute the basic quality control documents at all stages of fabrication. The inspection plan provides for the actual dimensions measured by the inspector to be recorded in appropriate spaces on the plan, and for the inspection stamp indicating approval by the inspector. A typical inspection plan for detail part inspection is shown in Fig. 8.

When all phases of the manufacturing inspection on the detail part have been completed, the part is tagged with the serial number of the inspection plan and the plan filed by the Quality and Reliability Assurance Unit. As the part is installed, along with other detail parts in a component or higher level of assembly, an assembly detail record noting the serial numbers of the detail inspection plans and the names of the detail parts is prepared. On completion of the assembly inspection, in accordance with the inspection plan prepared for that particular assembly, the assembly is tagged to indicate the serial number of its individual inspection plan and the inspection plan, together with the assembly detail record, is filed.

ROCKETDYNE •

PROD RECORD | **PROD RECORD**

PART NO.

PART NAME | PAGE OF

NEXT ASSEMBLY

PLANNER | QUANTITY PER ENG. L.H. R.H. N.

NO. ENGINES	TOTAL PIECES THIS ORDER L.H.	R.H.	N.
SPLIT BY			

MODEL OR SYSTEM

THIS COPY USED ON ENGINE

MODEL OR SYSTEM

THIS PART EFF. ON ENGINE

DATE ISSUED | S. O. OR SP. ITEM | I W C

ACCOUNT | CONTRACT | ITEM OR REL. | WORK DONE FOR

INDEX/ HDW. | CYCLE | INITIAL STORES | FINAL STORES

TYPE ORDER | RECEIVING DATE | AUTH. DOC.

NTC REL	S. O. OR SP. ITEM	L.H.	R.H.	N.

LINE NO	DEPT. OR ENG. QTY.	OPERATION OR MATERIAL	TOOL TYPE	TOOL NUMBER R	C	T	E	TOOL DEPT	SCN	SCHEDULE N	D
1											
2											
3											
4											
5											
6											
7											
8											
9											
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11											
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Figure 7. Production Order

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION INC

INSPECTION PLAN

☐ SPACE ENGINES ☐ NUCLIONICS	☐ RESEARCH ☐ HIGH ENERGY FORMING	☐ ______	PROGRAM	
ROCKDYNE PART/SPEC. NO	CHANGE LTR	SERIAL NO.	PART NAME	
ORDER NO. ☐ PRODUCTION ☐ PURCHASE	SUPPLIER PART NO	SUPPLIER		
	RECEIVING REPORT NO.	NEXT ASSEMBLY NO.	DATE INSP	QCIP FOR ______ PIECE LOT

CHARACTERISTICS							
NO.	CLS	DESCRIPTION	DWG LOCATION	ACTUAL MEASUREMENT	INSP	SPECIFICATIONS AND EQUIPMENT

• DETAILS OF NONCONFORMANCE ARE SHOWN ON OPPOSITE SIDE — PAGE ___ OF ___

Figure 8. Quality Control Inspection Plan

This process of "pyramiding" the inspection plans is continued at all levels of subsystem and system assembly to completion of the end item for delivery. In this manner, complete and detailed inspection findings of each part of the final assembly are available for analysis at any stage of the fabrication process.

Where a functional test is required at any stage of inspection, a test plan is provided which specifies the test to be performed and allowable limits within which the part will be considered to have passed the test. This test plan is referenced to applicable specifications which provide test setup and operating information for performing the test, including measuring and test equipment to be used, and exact methods of manipulating controls and measuring parameters.

On completion of end-item fabrication, the inspection plans and related documents constitute a permanent history of the product and become part of the quality program documentation.

<u>Quality History Cards</u>. In addition to the inspection plan, which provides a record of inspection results and test information, the Quality History Card (Fig. 9 and 10) is used to record the permanent history of a single part or group of parts. The card form provides for entries of pertinent production data, inspection and materials review information, dispositions of parts, and records of corrective actions initiated in cases of failure.

When all card entries are complete, the card is processed and tabulated by electronic data processing equipment. The results are then available to serve as a basis for various levels of management reporting, and for quality analyses resulting in corrective action reports. The data are

~~CONFIDENTIAL~~

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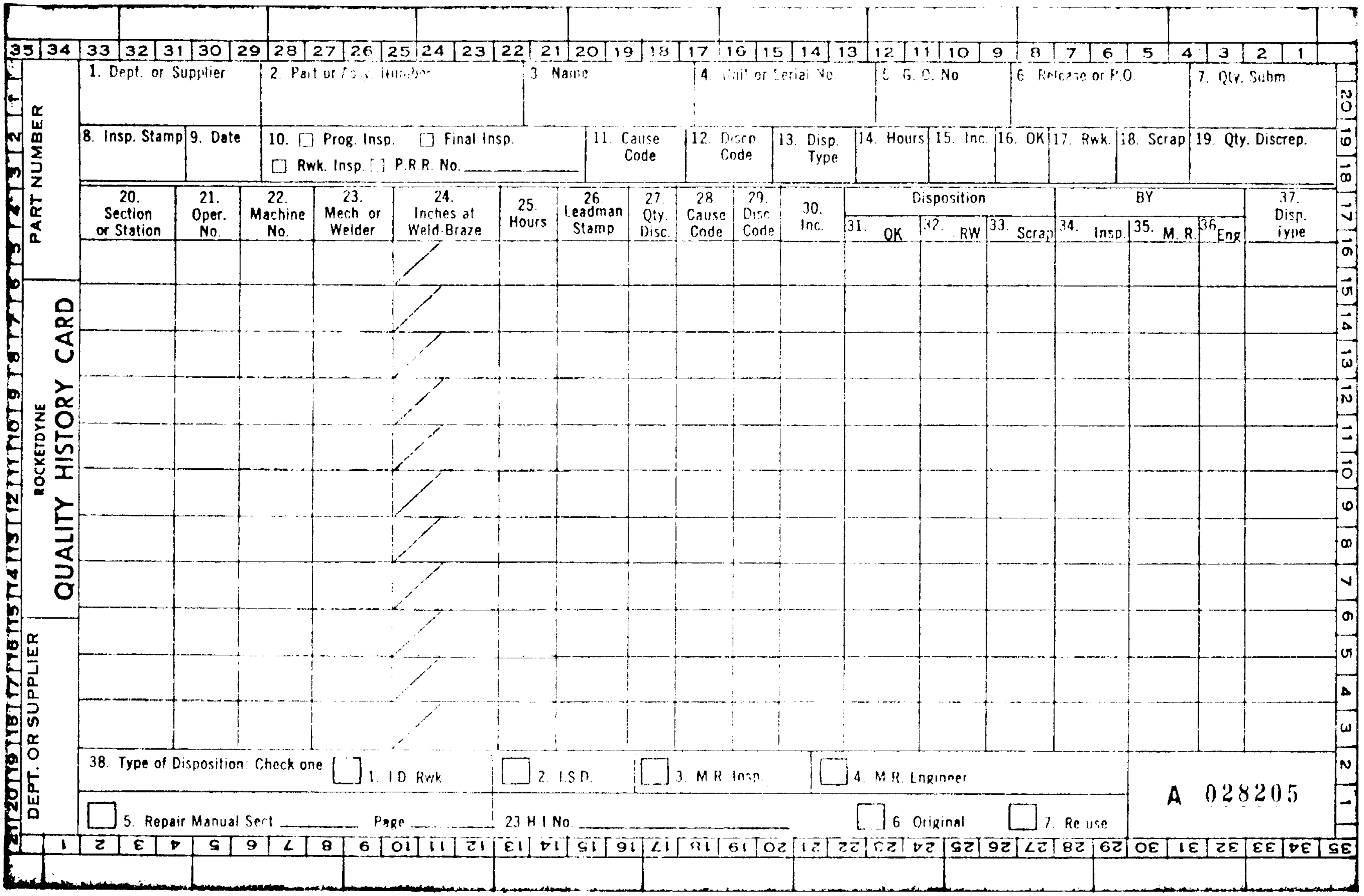

Figure 9. Quality History Card (Front)

~~CONFIDENTIAL~~

39. Oper. No.

40. DISCREPANCY DETAIL & REWORK INSTRUCTIONS

FORM 609-R Rev. 10-58

41. CORRECTIVE ACTION REQUIRED ☐ Signed ____________ Title ____________

42. CORRECTIVE ACTION

Effective on Unit No. or Date:

PRODUCTION SUPERVISION:

Figure 10. Quality History Card (Back)

also used to establish a quality performance record for particular Rocketdyne departments and suppliers.

Inspection Sign-Off Books. All inspection records for a particular assembly or system are incorporated into an Inspection Sign-Off Book. These books are used to (1) outline and record the exact sequence of production and inspection operations, (2) compile and correlate the various forms and records, (3) provide a means of controlling the quality of the installations or operations, and (4) evaluate the results obtained by the controls and records.

The sign-off books contain completed inspection plans on detail parts, and completed inspection plans, test plans, and assembly detail records on components, subassemblies, and assemblies. The books also serve as a repository for other documents such as inspection shortage forms, inspection discrepancy and correction records, and forms pertinent to particular programs. Illustrations of these forms are included in Appendix A.

Change Control

Changes to documents affecting the quality program are accomplished by the Rocketdyne release system. At appropriate points prior to delivery of the end-item, an Engineering Order (EO) is issued to authorize the release or cancellation of engineering requirements, and to distribute drawings, specifications, and other engineering information (Fig. 11). Changes made prior to delivery on a production contract and changes made after end-item delivery which require customer approval are incorporated into an Engineering Change Proposal (ECP) and submitted to the procuring agency prior to implementing the change.

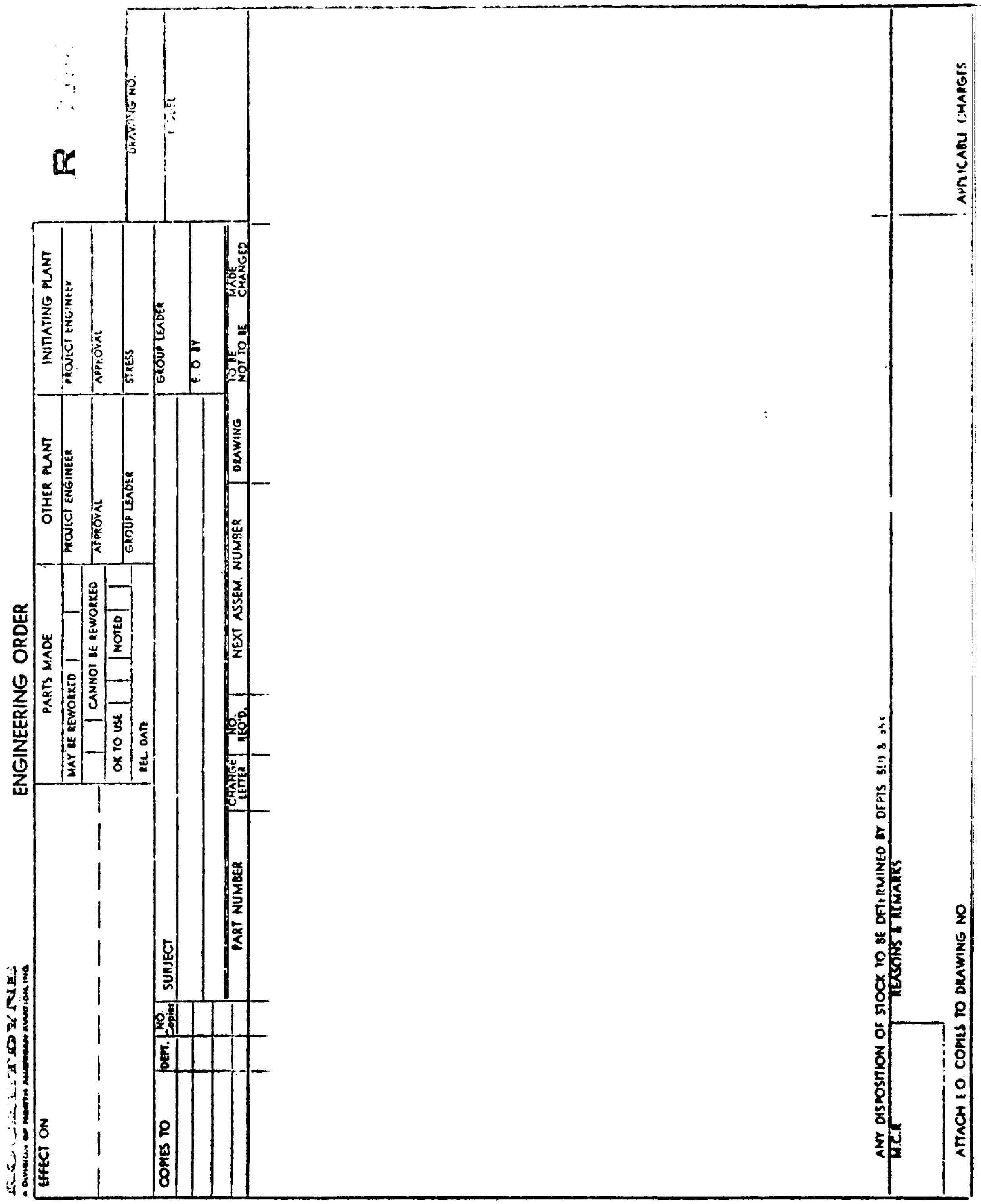

Figure 11. Engineering Order

The timely release and distribution of document changes to all affected functions is the responsibility of the Engineering Data Group.

On release of a change document all previous documentation, including production orders and inspection plans, are updated in accordance with the change. When an EO is issued to cancel a previously released drawing or other document, a statement is included on the EO to "Remove and destroy all prints in file." When an EO is released to add or delete an item of hardware that will affect the next assembly, the complete change to the next assembly is released simultaneously on the EO, or by release of a changed component drawing.

Responsibility for monitoring the effect of these changes, and for maintaining interface relationships is the function of the engineering design group. Prior to release, the change document is carefully reviewed to determine the effect on other assemblies or systems.

Effectivity

The effectivity of all item changes is noted on the change document. Change points are established to be compatible with hardware schedules and in accordance with good engineering and production practices. Where changes cannot be realistically accomplished prior to end-item completion, provisions are made to effect the changes to existing hardware on a retrofit basis. All affected items and accompanying documentation are coded and physically marked to show the appropriate modifications.

All items modified on a retrofit basis are inspected and tested in accordance with applicable specifications to ensure quality and reliability of the modification. Items modified during buildup are subjected to the routine inspection and testing, as required by the inspection plan.

COMPONENT QUALIFICATION TESTS

All components delivered to the customer are qualified in accordance with test schedules established by the engineering design groups. Results of these qualification tests are documented and made available for evaluation by Rocketdyne and customer representatives.

Parts, components, and high levels of assembly are uniquely identified by the use of serial numbers. This serialization allows a review of the complete history of parts and components at any stage of the fabrication process, as required.

CONTROL OF CONTRACTOR-PROCURED MATERIAL

Over the years, Rocketdyne has developed a system of determining potential quality control capability of procurement sources, and of monitoring and controlling the quality of supplier products. This system provides for quality control surveys, purchase order review, supplier product inspection, and supplier assistance programs, where required, to ensure adequate performance in delivering products to required quality standards.

SELECTION OF PROCUREMENT SOURCES

Suppliers are initially investigated by representatives of the Rocketdyne Purchasing Department. When the Purchasing Department is satisfied with items such as supplier financial stability and agreement with standard terms and conditions, a joint survey of supplier facilities is conducted by the Materials Department and the Procurement Quality Control Unit. The Materials inspection is concerned with management and manufacturing capability to fulfill schedule commitments. The quality inspection is made to evaluate adequacy of supplier manufacturing inspection procedures and acceptance criteria, accuracy and compatibility of measuring and test equipment with the product being procured, and adequacy of packaging, packing, and marking procedures.

When survey results indicate that the supplier has implemented and agreed to maintain an acceptable quality control program, he is considered capable of supplying products consistent with Rocketdyne quality standards.

Throughout the period of supplier performance Rocketdyne performs receiving or source inspections, as applicable to monitor quality of the procured product. These inspections are performed in accordance with requirements of the quality control inspection plan and related documents, as previously discussed under "Control Documentation." In addition, periodic audits of supplier performance, and resurveys of supplier facilities are conducted to ensure continued compliance with Rocketdyne and customer quality and reliability provisions.

In this manner, a level of experience is established with each Rocketdyne supplier. Quality History Cards and other quality records are compiled to provide a continuous record of the acceptability of supplier performance. This record, in turn, is used to provide criteria for future procurements.

PROCUREMENT DOCUMENTS

All procurement documents related to supplier products are subjected to review by the Procurement Quality Control Unit prior to release. This purchase order review consists of ensuring that the procurement documents are complete with respect to item identification, provision for government and Rocketdyne source inspection, where required, conformance with qualified products and qualified source lists, and other special requirements that may affect quality. Where government source inspection is required, this action will be specified in an appropriate statement on the purchase order

In addition to the purchase order, the supplier is provided with copies of the inspection plan, drawings, and specifications for the product to be procured. These latter documents also comprise part of the "bid set" on which the suppliers submitted quotations. Rocketdyne will require that the suppliers quality program conform to NASA Quality Publications, as applicable, except on rare occasions when the critical nature of the program requires the temporary procurement of parts from proprietary sources. In these situations, Rocketdyne will verify conformance of the procured product to all quality and reliability requirements.

SOURCE INSPECTION

Provisions are made, as applicable, for government and Rocketdyne source inspections to be performed at the supplier's plant. Source inspection performed by and for the convenience of the government does not relieve Rocketdyne or the supplier of the responsibility for ensuring the quality of the delivered products.

Rocketdyne source inspections are performed: (1) when necessary test equipment is not available at Rocketdyne, (2) when it is expedient to check an item in the process of fabrication, assembly, or processing, (3) when destructive testing or excessive disassembly would be required during receiving inspection, (4) when the end item is to be delivered directly to the customer or facility other than Rocketdyne, or (5) when it is more economical.

Source inspection ensures that the product conforms to applicable drawings, specifications, and other requirements stipulated in the purchase order. When inspecting Rocketdyne-designed assemblies, the inspector completely inspects the detail components of the first assembly for conformance to drawings and specifications. He also checks processing, materials, and supplier records to verify that approved materials and processing sources have been used, and expedites the accomplishment of functional and pressure tests.

The extent of detail inspection required prior to welding, plating, or similar operations is determined by the inspection plan. All pertinent information for the completion of unfinished operations or inspections is entered on the Quality History Card or other approved forms which are delivered, along with the supplier product, for Rocketdyne receiving inspection.

Rocketdyne inspectors, on receiving a supplier product that has been subjected to source inspection, determine that necessary source inspection and processing stamps are affixed to the record and to the part, that parts are identified, and that any further inspections or tests noted on the Quality History Card or inspection plan are performed.

RECEIVING INSPECTION

On receiving a supplier-fabricated product, Rocketdyne conducts an inspection in accordance with the established inspection plan for the item. Characteristics of the product are verified in addition to, or in conjunction with, requirements of the purchase order, drawings, and specifications to determine acceptance or nonconformance. The status of product qualification is also reviewed during receiving inspection. Where components have not been qualified previously, it is the responsibility of the inspection function to ensure that qualification tests are satisfactorily completed prior to delivery of the Rocketdyne product.

Materials, such as synthetic rubber products, which are subject to deterioration by aging, are inspected to ensure that cure date markings and age limitations have not been exceeded. Raw materials will be checked against requirements of applicable specifications and for conformance to the supplier's test report, which is required to accompany the shipment.

Prior to completion of the receiving inspection, supplier-furnished products and materials are physically separated to maintain integrity of the lots. After inspection, the materials are transferred to a warehouse where continuing identity, as well as proper storage conditions, is maintained.

FAILURE AND DEFICIENCY FEEDBACK

Where nonconformances to drawings are found in supplier products or materials, a report (Fig. 12) is completed by the inspector to show the characteristics that do not conform. This report is forwarded to the Purchasing Department where a letter is written by the Buyer to a responsible officer of the supplier organization. A copy of this letter is forwarded to the Quality Assurance Unit for followup and coordination. In addition to informing the supplier of the nonconformance, it is requested that the supplier notify Rocketdyne Quality Assurance, prior to the next shipment, of the actions taken to prevent future deficiencies.

The effect of this action is to ensure that the supplier is promptly notified of the nonconformance, that corrective action is quickly implemented, and that a single point of contact (the Buyer) is maintained between Rocketdyne and its suppliers.

Nonconformances encountered by source inspection and/or receiving **inspection will be listed on this form by the receiving inspector prior to final disposition of the hardware.**

RECORD OF SUPPLIER NONCONFORMANCE

SUPPLIER'S NAME ____________________ P.O. NUMBER ____________________

BUYER ____________________ PART NUMBER ____________________

PART NAME ____________________

SPECIFIED CHARACTERISTIC	NONCONFORMANCE

Inspector ____________________

Figure 12. **Record of Supplier Nonconformance**

SUPPLIER RATING AND PREFERRED SOURCE LISTS

The use of the Quality History Card in compiling preferred source lists has previously been discussed. In addition, Rocketdyne has developed a method of rating based on the cost of doing business with suppliers producing items in the same product category.

Supplier performance, as tabulated from the Quality History Cards, is analyzed to provide two basic indices: cost rating percent, and quantity rating percent. These indices are derived by the formulae:

$$R_c = \frac{C_c}{C_c \quad C_r} \times 100$$

and

$$R_q = \frac{S_q}{I_q} \times 100,$$

where:

C_c = contract cost

C_r = Rocketdyne cost (includes cost of all inspections and materials review, rework, and repair)

I_q = quantity inspected

S_q = quantity released to stores

Supplier performance data collected from the Quality History Cards include:

1. Part and category
2. Hours expended by Rocketdyne

3. Part dispositions

4. Discrepancy details

5. Unit cost of parts

From this information, supplier performance analysis reports are prepared and coordinated for each low-performance supplier. The reports define problem details, actions taken, and action required. Copies of these reports are forwarded to the Purchasing Department Buyer who, in turn, contacts the supplier to require that corrective action be taken.

CONTROL OF GOVERNMENT-FURNISHED PROPERTY

INSPECTION OF GOVERNMENT-FURNISHED PROPERTY

All government-furnished property (GFP) is stored separately from company property prior to receiving inspection. Segregation of serviceable property is also maintained separately from reparable or unserviceable GFP. The GFP is processed and stored to prevent damage from handling or exposure.

Incoming GFP is checked against the shipping voucher or receiving report to determine that applicable contract numbers, consignee, part numbers, and quantities are in agreement. The property is also checked against the accompanying tag or label, noting condition of the item, inspection and reinspection dates, and other information such as storage conditions and limitations.

Prior to further processing or installation, the GFP is functionally tested in accordance with applicable specifications. Where no discrepancies are found, the appropriate document is stamped to show acceptance.

DEFECTIVE GOVERNMENT-FURNISHED PROPERTY

Where GFP is found to be defective, Rocketdyne will advise the cognizant government agency. Pending disposition of the defective equipment, the GFP is properly stored to prevent further damage or increased repair costs.

CONTROL OF CONTRACTOR-FABRICATED MATERIAL

The basis of Rocketdyne quality assurance is provided by the control documentation previously discussed. It is Rocketdyne's intent to conscientiously apply these established plans and procedures to ensure delivery of products conforming to highest industry-wide standards of quality and reliability.

Inspection and test plans developed for parts, components, and higher levels of assembly are supplemented, as necessary, by Rocketdyne and contract specifications to provide conformance criteria. Inspection and test plans, as previously indicated, are based on engineering design requirements, quality characteristics of the product, review of materials and manufacturing considerations, and analysis of over-all requirements determined at the time of design review.

Particular emphasis is placed on inspection and testing at points that minimize potential production delays through early detection of deficiencies. Products fabricated by Rocketdyne and its subcontractors are subjected to inspections at the part, component, and higher levels of assembly. Workmanship samples, where required, will be provided for customer inspection and use.

Tests and final inspection of the end item are conducted in accordance with the Rocketdyne model specification for the delivered product. An outline of an engine model specification is shown in Appendix B. Results of these final acceptance tests and inspections are documented in the Rocketdyne Engine Log Book. This book, containing the final production documentation prepared prior to end-item delivery, will be delivered to the customer along with the product.

In addition to a technical description of the system, test documentation, and engineering and performance data, the log book contains a historical record of engine components and a component replacement record to show changes made during engine buildup. An outline of a Rocket Engine Log Book is shown in Appendix C.

Any modifications scheduled after final tests and inspection of the end item are accompanied by an inspection plan to be verified by a competent inspector.

FABRICATION CONTROLS

Production Tooling and Fabrication Equipment

All gages, used to compare physical characteristics of a product to specified dimensional requirements, and all measuring tools used for measuring specific characteristics of a part, assembly, or tool, are identified by unique serial numbers. These gages and measuring tools are initially inspected and tested prior to use. Where tooling is designed by Rocketdyne, the tool drawings are checked by Quality Assurance personnel prior to fabrication. The finished tools are also checked against the drawing requirements. A historical record is then prepared to show the tool name, serial number, and the required intervals between reinspections.

Material Control

Prior to use, materials employed in the fabrication of Rocketdyne products are held in a warehouse, where the item identification is maintained along with the inspection plans, which provide traceability of the materials back to their sources. When released for manufacturing, the materials are tagged for identification and referenced to the serial numbers of their individual inspection plans. During the manufacturing process, material identification is maintained by use of the inspection plan system, as previously described. Nonconforming material found at any stage of the fabrication process is immediately removed from the work area and stored in a bonded area pending further disposition.

All controlled processes or operations of a critical nature used during product fabrication are closely monitored and protected against contamination. Baths for cleaning and plating processes are periodically sampled to ensure that chemical composition, pH values, levels of contamination, and similar attributes are maintained within specified tolerances.

Identification of age-limited material or material that deteriorates because of use, temperature sensitivity, or other environmental factors is indicated either on the product or on accompanying documentation. Assembly dates of age-dated materials and the number of actuation cycles of use-limited parts are recorded and used to control installation of these materials during product buildup. These records, including a chronological history of component replacement in the delivered product and remaining useful life of installed materials, are included in the Rocket Engine Log Book which accompanies the product into the field.

Cleanliness Control

Cleanliness of close-tolerance parts or critical fabrication processes is controlled by Rocketdyne specifications for the particular operation. The necessary procedures are conducted in limited-access areas in which environmental conditions are controlled; solutions are filtered, temperature and atmospheres regulated, and special clothing worn by operating and inspection personnel.

Requirements for this type of handling are specified on the engineering drawings released for product fabrication. In addition to establishing the special handling requirements the applicable process specifications are referenced on the drawings.

PROCESS CONTROL SPECIFICATION AND PROCEDURES

Rocketdyne has developed methods of defect prevention for controlling critical processes in which the quality of product cannot be determined solely by inspection. The basis for these control methods is contained in the Rocketdyne process specifications covering over 1500 different operations and processes. These specifications, in all cases, equal or exceed applicable military specification requirements.

Each specification contains all necessary information for the operator to perform the indicated process and includes, scope and application of the specification, materials required, and a step-by-step procedure for accomplishing the task. A sample Rocketdyne process specification is included as Appendix D.

Equipment, machines, and operating personnel used for performing critical processes are certified by the Rocketdyne Production Development Laboratory. The equipment is inspected, calibrated, and tested during operation as part of the certification process. Requalifications are conducted, as necessary, in the event of changes to the process specifications or modifications to the equipment.

In addition to maintaining records and results of the certification tests, the Production Development laboratory is responsible for the training and certification of operating and inspection personnel. This responsibility is discussed in detail in a later section of this document.

NONCONFORMING MATERIAL

Where nonconforming material is found at any stage of the fabrication or inspection process, the material is immediately removed from the work area, physically stamped to show that it is nonconforming, and stored in a bonded area pending further disposition. Disposition of these materials is made by the Material Review Board except in cases of (1) minor nonconformances that can be reworked and reinspected to meet drawing and specification requirements, and (2) minor nonconformances of appearance and workmanship which do not affect performance of the product.

The Rocketdyne Material Review Board is comprised of the chief engineer, the manager of Quality Assurance, and the chief Quality Control representative of the customer's inspection agency. Duties of the board consist of reviewing all nonconforming materials presented for their action and providing the final judgment on (1) items that can be reworked for use but will vary from drawing requirements, (2) items that can be used "as is," or (3) items that are to be scrapped. Review Board members are supported, as required, by consultants from other Rocketdyne operating functions.

Items determined to be acceptable in "as-is" condition are limited to nonconformances which will not affect operation, reliability, or interchangeability of the part. Decisions involving use of "as-is" or reworkable items must be made by unanimous agreement of board members. Where Material Review Board action determines that parts are or can be made acceptable for use, a material review stamp is applied over the nonconformance stamp, and the item returned for use.

Rocketdyne does not anticipate requesting the Contracting Officer to relax contract requirements in areas of safety, reliability, durability, performance, or interchangeability of products. Neither does Rocketdyne anticipate delegating material review authority to subcontractors or suppliers.

INSPECTION, MEASURING, AND TEST EQUIPMENT

All inspection, measuring, and test equipment used in the fabrication of Rocketdyne products is controlled throughout the useful life of the equipment by inspection, calibration, maintenance, and repair to ensure continued suitability for use.

Drawings for Rocketdyne-designed equipment and requests for the purchase of commercial items are reviewed by quality control tooling specialists to determine that the equipment to be procured is adequate for the purpose intended. Upon receipt of the completed equipment, it is inspected and functionally tested, as required, to determine that it conforms to the design or manufacturer's specification.

Test equipment, including measuring instruments and systems, console-type test equipment, and test instruments, is certified prior to use by the Rocketdyne Production Development Laboratory. This laboratory has been established to provide measurement standardization and other technical services throughout Rocketdyne. The Production Development Laboratory is staffed with graduate engineers and other technical specialists selected on the basis of competence in their fields of activity. In addition to determining that the equipment conforms to specifications, the certification process requires that operation of the equipment be demonstrated in use on a deliverable end-item.

Gage-type measuring devices are issued and maintained through a Tool, Gages, and Instrument Control Sheet, which is used to prepare an IBM gage inventory book. This document contains a listing for each gage in use at Rocketdyne to show gage name, serial number, and required intervals between calibrations. The calibration schedules are based on gage type, stability characteristics, purpose, and degree of usage. These intervals range from "each use" for such items as thread gages to "yearly" for granite surface plates. Additional inspections and recalibrations may be requested by inspection or operating personnel, where required.

In addition to the gage inventory book, an individual historical record card is prepared for each gage. This card is filed in the tool crib from which the gage is issued for use. A daily inventory is made of these cards to ensure that the periodic calibration schedule is maintained, and that records of calibrations and maintenance services are entered on the cards.

Instruments such as pressure gages, electrical test meters, and flow measuring devices are calibrated, issued, and maintained by the Manufacturing Inspection Department. The Production Development Laboratory provides support, as required, and approves, inspects, and calibrates "first-of-a-kind" instruments and equipment procured by Rocketdyne. The Production Development Laboratory also specifies calibration and maintenance procedures for the instruments. (An example of a Production Development Laboratory Instrumentation Instruction is shown in Appendix E.)

Instrumentation calibration schedules are controlled by void-date labels affixed to the instruments. Prior to the expiration dates, the instruments are returned to the Manufacturing Inspection Department for calibration and maintenance, as required. Records of calibrations and services performed are maintained in the Manufacturing Inspection Department files.

All working standards used for inspection and calibration of measuring tools and gages are calibrated to primary standards maintained by the Production Development Laboratory, which are traceable to the National Bureau of Standards. Within state-of-the-art limitations, standards used for calibration of inspection, measuring, and test equipment have a tolerance no greater than 10 percent of the allowable tolerance for the equipment being calibrated.

INSPECTION STAMPS

Rocketdyne has established a system of inspection stamping to indicate that a part physically and functionally complies to applicable drawings, specifications, and other information controlling part configuration and quality. In addition to acceptance stamps, parts are stamped to indicate the acceptability of X-ray, magnaflux, heat treat, hydrostatic pressure test, and similar processes. A complete stamp catalog of Rocketdyne stamps is shown in Appendix F.

Inspection stamps are placed on parts in the areas designated by the part detail drawing. When a specific area is not designated, the stamp is placed adjacent to the part number. Stamped tags are used where size limitations, configuration, or materials prevents stamping of individual parts.

Inspection stamps, traceable to the individual, are issued only to qualified inspectors. Records of stamp assignment are maintained to show the inspector's name, clock number, location and department, type of stamps, and date of issuance. When an inspector terminates, his stamps are removed from further use for a six-month period. When a stamp is lost, the remainder of the set is placed in bond for one year, and a new set issued.

PRESERVATION, PACKING, HANDLING, STORAGE, AND SHIPPING

All preservation, packing, handling, storage, and shipping requirements are specified by the Rocketdyne process specification covering these items, the product model specification, and special requirements listed on the applicable engineering drawing. Prior to delivery of the end product, quality control personnel ensure that all necessary tests and inspections have been performed, appropriate quality and inspection records accompany shipment of the product, and that adequate provisions have been made for protecting the product during transit and storage.

Rocketdyne Process Specification RA 0116-027 incorporates, by reference, military and North American specifications for processing special products, and outlines procedures for: cleaning and drying, maintenance of cleaning solutions, applying masking and protective closures, using preservative compounds, wrapping, cushioning, and packaging methods. The specification also outlines the procedures for conducting operational requirements tests for various methods of packaging: quick-leak, waterproofing, vacuum-retention, pressure-retention, heat-seal, cleanliness, and contact preservation continuity and appearance tests.

When the product is received for shipping inspection, it is checked to determine that it conforms to the latest mandatory engineering drawings; is properly identified and marked; and is complete with respect to quantity, inspection and other documentation, and inspection and processing stamps.

After the product has been subjected to customer inspection and acceptance, it is prepared for shipment in accordance with instructions provided by packaging engineers for the specific item involved. These preparations include, as necessary, ensuring that: (1) assemblies and critical surfaces are cleaned, preserved, and protected in accordance with applicable specifications, (2) protective covering of openings are accomplished to prevent entry of foreign material, (3) preservation compounds are maintained at the prescribed temperatures, and (4) cleaning agents and preservation compounds are free from contamination, and are correctly labeled and stored.

Shipping documentation is then checked for completeness with respect to item identification and marking, inclusion of necessary shipping and technical documents, and adequacy of shipping and handling instructions to ensure safe arrival and ready identification at the destination.

STATISTICAL PLANNING, ANALYSIS, AND QUALITY CONTROL

Statistical analysis and test planning are used during the engineering development testing program when such measures are considered advantageous. Statistical quality control methods are used in manufacturing, testing, and procurement quality control systems at Rocketdyne and supplier facilities.

Sampling plans are used only where acceptance tests are destructive or where the number of parts fabricated justify their use. Where these plans are used, they conform to requirements of MIL standards 105, 414, or other sound statistical plan concurred upon by the customer.

Statistical quality control methods are especially designed to fit individual applications, with primary considerations given to improved quality and reduced cost. The use of statistical methods is based on evaluation of products, methods, and areas. Where possible, existing inspection records are used. However, special data collection systems may be installed for the evaluation of a given part or parts.

Prior to implementation of the statistical methods plan, the plan is reviewed to determine the nature, extent, and application of the program; the extent and nature of the training required; and the economic aspects resulting from use of the plan, including the cost relationship between existing and proposed plans.

After the plan is adopted, Quality personnel are responsible for auditing or monitoring all statistical applications to ensure that the plans are properly used, and that the plans are modified as necessary to coincide with product changes. Quality control charts are used in these monitoring procedures where the number of parts to be controlled or the complexity of the operation makes use of these charts desirable.

TRAINING AND CERTIFICATION OF PERSONNEL

Training programs, orientation lectures, and certification procedures are conducted to develop qualified personnel engaged in the fabrication and quality control of Rocketdyne products. These educational programs are directed by qualified specialists selected from among the Rocketdyne staff who are capable of imparting their knowledge and skills, and who are capable of measuring the proficiency of the trainees. Particular emphasis is placed on training and certifying personnel working in critical areas such as those of welding, soldering, wiring, radiographic, magnetic particle, dye penetrant, and bonding operations and inspections.

Nondestructive test inspection, either by interpretation of test indications or by acceptance or rejection of deliverable parts is performed only by inspectors certified for the specific type and class of inspection involved. The applicants for certification are required to complete a course of instruction, as outlined by the Rocketdyne Production Development Laboratory, for each type and class for which certification is requested. These courses include: (1) inspection theory and operational techniques; and (2) inspection duties and responsibilities, as specified in Rocketdyne documents. Certification examinations, written and functional, are then conducted by personnel designated by the Production Development Laboratory.

Upon successful completion of the required training and examinations, applicants are certified and certificates issued showing the areas in which the applicant is qualified.

The certificates are valid for one year and may be renewed by demonstration of continued high standards of workmanship. However, at least once in every five-year period the certificate holder is required to demonstrate his ability by again passing the certification examination.

Similar certification procedures are in effect to control critical fabrication techniques such as welding. In addition to training and certification of welders, the Production Development Laboratory maintains a proficiency record for each welder, based on the inspection records of welding quality.

Additional controls over performance quality are maintained by measures such as periodic eye examinations for inspectors. All personnel assigned to inspection functions are required to demonstrate visual acuity for near and distant vision, depth perception, and color discrimination.

DATA REPORTING AND CORRECTIVE ACTION

As previously indicated, the basis of Rocketdyne quality assurance is provided by the control documentation described elsewhere. These documents, namely the inspection plans and the Quality History Cards, also provide the basis for collection, analysis, and reporting of quality and failure data, and for implementing corrective action measures.

Analysis of the completed inspection plans at all levels of assembly in conjunction with a review of the Quality History Cards affords a broad over-all indication of the quality program status. At the same time, evaluation of inspection plan entries provides an essential tool for pinpointing potential trouble spots in the fabrication operation. Tabulation of data from the Quality History Cards also provides an effective means for the rapid transmission of quality findings and trends for management use.

DATA REPORTING

Rocketdyne does not presently issue formalized periodic reports on the quality assurance program except as required by specific contracts. However, the present data collection and analysis system described in the preceding paragraph is considered adequate to allow reporting, as required. A schedule for the submission of quality program reports, as required by NASA Quality Publication NPC 200-2, is shown in Table 2.

TABLE 2

DOCUMENTATION SCHEDULE

(Ref: Appendix B, NPC 200-2)

Document	Submitted For	Schedule
Qualification Status List	Approval	As requested
End-Item Test Plan	Approval	30 days prior to delivery of first production prototype
End-Item Test and Inspection Procedures	Approval	2 weeks prior to implementation
Quality Program Plan (Final)	Review	45 days after approval of preliminary plan
Test and Inspection Procedures	Review	2 weeks prior to implementation
Process Control Procedures	Review	2 weeks prior to implementation
Results of Special Measuring and Test Equipment Evaluation	Review	As applicable
Storage Procedures for End Items	Review	2 weeks prior to implementation
Special Sampling Plans	Review	2 weeks prior to implementation
Monthly Quality Status Report	Information	20 working days after period reported
Quarterly Summary of Audits	Information	30 working days after period reported

CORRECTIVE ACTION

Requests for corrective action may be originated by the customer, by any of Rocketdyne's quality assurance or inspection functions, or as the result of inspection plan and Quality History Card analyses by the Quality and Reliability Assurance Unit. An example of the method for acquiring corrective action in the case of a supplier has been previously described. The method for acquiring corrective action within the Rocketdyne organization is accomplished through the Operation and Failure Report and the resultant failure analysis report system. This report contains information identifying the part, describing the failure, indicating the stage of the operation or inspection at which the failure was encountered, and recording the disposition of the failed part. Sample report forms are shown in Fig. 13 and 14.

The Quality and Reliability Assurance Unit serves as a central point for processing all corrective action requests, contacting the responsible operating functions (except suppliers), and ensuring that appropriate action is implemented without delay. Personnel of this unit also perform an analysis function to indicate whether the source of the nonconformance is a design problem, a nonconforming material, or a faulty production operation. These personnel are uniquely qualified to perform these analyses because of training and experience, and because they are sufficiently removed from the line operation to provide effective and objective judgment.

Corrective action requests initiated by the customer or by Rocketdyne field representatives will be processed in a similar manner. Quality assurance functions and analysis at field and operational sites are implemented where they are considered necessary and practical.

Operation and Failure Report
ROCKETDYNE

FAILURE — OPERATION — PROGRAM — LOCATION
PART CHANGE
FAILED ITEM — TIME EXPIRED — TO DELETE

№ 01746R

PART IDENTIFICATION

1 PART NO — 2 PART NAME
3 SERIAL NO — 4 MFG NAME — 5 MFR CODE — 6 REF DESIG
7 NEXT ASSY PART NO — 8 NEXT ASSY SERIAL — 9 NEXT ASSY NAME
10 MISSILE SERIAL NO — 11 ENG AGE MODEL NO — 14 SYSTEM CODE — 15 COMPONENT CODE
12 REJ TAG NO — 13 ENG AGE SERIAL NO — 16 HARDWARE CODE

PART DISPOSITION / PART REPLACEMENT

PART DISPOSITION	PART REPLACEMENT
1 REPAIRED IN PLACE	1 IDENTICAL ITEM
2 REPAIRED & RE-INSTALLED	2 SUBSTITUTE PART
3 ADJUSTED	3 NONE
4 ELIMINATED	4 NONE AVAILABLE
5 CONDEMNED	REPLACEMENT PART NO
6 HOLD FOR REPAIR	
7 DEPOT REPAIR	
8 FAILURE ANALYSIS	REPLACEMENT SERIAL NO
9 USED AS IS	

39 FAILED PART SENT TO
40 — 41

FAILURE/OPERATION DATA

FAILURE DATE (YR MO DAY) — 18 TEST REPORT DATE (YR MO DAY) — TEST OPER NO — 20 ITEMS
21 PROCEDURE SPEC & PARAGRAPH
FS — SV — NC — 25 FAIL TYPE — 26 FAIL CODE — 27 SECONDS — 28 STARTS — 29 MONTHS — 30 NOT A RELEVANT NO — 31

32 OPERATION REPORTED OR IN PROGRESS

A	COMP ASSY TEST	H	MAINTENANCE	34 TIME PERIOD
B	FINAL ENG ASSY	J	LEAK & FUNCTION	ACCEPTANCE STATIC TEST ONLY
C	ELEC MECH CHECK		SIM LAUNCH	PRE TEST
D	ACCEPT R&D TEST	K	MISSILE ACCEPT	
E	STORAGE	L	STAT MISS TEST	TEST
F	SHIPPING	M	PROPEL LOADING	
	RECEIVING INSP	N	PERIODIC INSP	POST TEST

REPORTED BY

42 NAME — ASSIGNMENT SHEET YES NO
45 APPROVED BY — 47 STAND AREA

ANALYSIS ASSIGNED TO

48 NAME — PART REQ YES NO

DATE REPORT RECEIVED — DATE REPORT DISTRIBUTED (MO DAY)

IBM USE ONLY — 1 / 2 — TAPE CODE

DESCRIPTION OF FAILURE

WHEN? WHERE? HOW MUCH? — CAUSE? EFFECT? COMMENTS?

TEST OPER NO 77 78 79 80 — A — B — C — D — E — F — G

16 REF OFR — 42 REF OFR — 48 REF OFR — 54 FAILED DETAIL PART NO

RELIABILITY ANALYSIS USE ONLY

IDENTIFICATION — TEST TYPE — 10 GROUP RESP CODE — 16 PA CODE — EF — AP — CF — FC — 24 LEAK — CONTAM — 30 PROP SYSTEM
36 NTH — COMP — 40 ASSY — RS 2 — CD — 46 — 65 DELETE
REPLACEMENT PART NO — 15 REPLACEMENT S N — 22 NAME — 25 TYPE — 31 MFR — 35
36 INSTALLATION PART NO — 50 CONFIG CODE — 57 NAME — 60 GR RESP — CH — CL — M — R — 78 80

OFR № 01746R

FORM ... REV ...

Figure 15. Operation and Failure Report

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION INC

RAPID SYSTEM **FAILURE ANALYSIS REPORT**

1. GENERAL

A FCDR NO	B DATE OF ANALYSIS	C FACILITY	D LOCATION

2. IDENTIFICATION

A FAILED ITEM NAME	B FAILED ITEM PART NO	C FAILED ITEM TYPE OR MODEL	D FAILED ITEM MFR	E FAILED ITEM SERIAL NO

F ENGINE GSE MODEL NO	G ENGINE GSE SERIAL NO	H	I	J

3 HISTORY 4 ANALYSIS 5 CONCLUSION 6 ACTION TAKEN USE SPACE AS NECESSARY FOR THESE ITEMS USE EXTRA SHEETS IF NECESSARY FOR COMPLETE ANALYSIS

1 FCDR NO 6 | 7 1ST LINE 40
41 | 49 2ND LINE 79 J

1 FCDR NO 6 | 7 | 18 3RD LINE 40
41 | 60 4TH LINE 79 K

1 FCDR NO 6 | 7 | 29 5TH LINE 40
41 | 71 6TH LINE 79 L

1 FCDR NO 6 | 7 40
41 7TH LINE (FROM 40) 79 M

1 FCDR NO 6 | 7 | 9 8TH LINE 40
41 | 51 9TH LINE 79 N

1 FCDR NO 6 | END OF DESCRIPTION | TEST NO | TEST TYPE | ACCUM SEC | STARTS | PD
41 REF FCDR | 47 REF FCDR | 53 REF FCDR | 60 B | D | F FAIL H CODE J | L | N | P | RESP O

1 FCDR NO 6 | ANAL YR MO DAY | BY | HWF | FA CODE | H | FA CODE | LEAK | CONTAM | FS | SN | EF | AP | CF | FO
DISTR YR MO DAY | 47 | 71 NTH | 74 IDENTIFICATION 79 P

1 FCDR NO 6 | COMP P N | COMP S N | NAME | COMP TYPE 36 | CH | CL | M | R
41 MFR 45 T | 47 NEXT ASSY P N 60 | 61 CONFIG CODE 67 | NAME | 71 GR RESP CODE 77 | COMP Q

FCDR NO

7 ANALYZED BY (NAME & GROUP)	8 APPROVAL

FCDR BY ______ LOCATION ______ DATE DISTR ______

FORM 610-C-61

Figure 14. Failure Analysis Report

AUDIT OF QUALITY PROGRAM PERFORMANCE

Periodic but unscheduled audits of the quality program operation are conducted by quality support personnel and, in the cases of suppliers, by the Procurement Quality Control Unit. The purpose of these audits is to monitor department conformance to established quality control operations, and to effect corrective measures where indicated. In addition to the periodic audits, requests for additional evaluation can be made by any quality assurance function or member of inspection supervision when it is felt that procedures are not being rigorously followed.

These audits take the form of evaluating quality operations and records, performance of inspection personnel and adequacy of procedures to attain required levels of quality and reliability of product.

Results of these audits and recommendations for correction of deficiencies are documented for management and customer use. These records are used as the basis for followup to ensure that deficiencies are corrected. These documents are also available to serve as the basis for quarterly summaries of the audits, as specified in Table 1 of the previous section.

APPENDIX A

INSPECTION SIGN-OFF BOOK

QUALITY CONTROL OPERATING PROCEDURE

Dept. and Plant: 554, 556 AND 654

TITLE: INSPECTION SIGN-OFF BOOKS

Approval
Robert L. Heath

APPLICATION

This procedure outlines the general methods and Quality Control requirements necessary to accomplish the Inspection Sign-Off Books as a comprehensive permanent historical record of the assembly, test and inspection of Rocketdyne engines and their systems or components.

Inspection Sign-Off Books are unique devices that have been developed to outline and record the exact sequence of production and inspection operations; to compile and correlate the various records and forms; to provide a means of controlling (by pre-determined steps) the quality of the installations or operations; to afford an objective method of evaluating the results achieved by these controls and records.

This procedure has been outlined as a reference and training guide for inspectors using Inspection Sign-Off (ISO) Books. The following index is for ready reference:

1. General: ISO Book Information
2. ISO Book Cover: Form R58-C or R58-C-1
3. ISO Records: Form 611-U (or equivalent)
4. Inspection Discrepancy and Correction Records: Form R 25-U
5. Materials Review Action: Form 609-R
6. Inspection Hot-Fire Time Sheet: Form 615-R
7. Part Removal Record: Form R 79-Q
8. Shortage Report: Form 61-Y
9. Serialization Record: Form 604-N-2
10. Orifice Records: Form 604-N-1
11. Thrust Chamber Repair Log: Form 607-N
12. Thrust Alignment: Forms 612-H Series
13. Safety Inspection Verification Sheet
14. MCR Verification List
15. Structural Approval and Materials Review: Form 60-W

- -

*Supersedes R-8.1 dated 28 JANUARY 1960. Complete revision.

1. GENERAL: ISO BOOKS

1.1 It shall be the responsibility of the Inspection General Foreman to establish the requirements for adequate Inspection Sign-Off Books that are necessary as a record when completing the fabrication, assembly, processing or test of any assembly in accordance with quality control requirements and applicable specifications.

1.1.1 The ISO Books will be prepared and assembled by the Process Control Group of the Planning Department in coordination with Manufacturing, Test and Inspection to contractual and Rocketdyne quality requirements.

1.1.2 Each inspector shall review the proper ISO Book before starting the inspection of a component requiring an ISO Book.

1.2 The accuracy and completeness of operation and inspection callouts in the ISO Books shall be the responsibility of Inspection Leadmen and Inspection Supervision. However, the Planning Process Group of the Planning Department is charged with the task of maintaining the ISO Book callouts current and in accordance with information furnished by Manufacturing and Inspection.

1.2.1 Neither Inspection nor Manufacturing shall make additions, changes or corrections to inspection or operation callouts in ISO Books. Due to the location and areas of operation at Neosho, the requirements of paragraph 1.2.1 of the ISO Book do not apply.

1.2.1.1 Inspection Leadmen or Manufacturing Leadmen shall notify the Process Control Group of the Planning Department of the discrepancy and request immediate correction.

NOTE: Inspection Leadmen, at Neosho, will submit any changes or additions to the ISO Book to Inspection Supervision for approval.

1.2.2 Advance copies of blueprint changes, Engineering Orders and Process specifications that require a change in sequence or numerical corrections to the ISO Book callouts shall be referred by the inspector to his leadman or supervisor and the final "buy-off" shall be held up by Inspection until the ISO Book changes are completed by the Planning Department. Inspection or Manufacturing leadmen or their supervisors, shall notify the Planning Department of the changes required and request their immediate action. Only in extreme emergencies will Inspection and Manufacturing supervision have the authority to approve necessary additions or corrections in the ISO Books.

1.2.3 Improvement changes to the ISO Book, such as additions, deletions or changes to the sequence of operations for the purpose of facilitating production methods or improving the quality of the product, shall require coordination by Planning, Inspection and Manufacturing. This coordination is only initiated by means of a Sign-Off Change Request, Form #101-P10, from Manufacturing or Inspection Supervision to Planning.

1.2.4 When an ISO Book is required for purposes other than a normal assembly or test it shall be issued by the Process Control Group of the Planning Department and the required identification information shall be noted by Process Control Group on the outside front cover, such as, REBUILT FROM # (original Assy. & Serial #), MODIFIED FROM # (original Assy. & Serial #), FINAL SHAKEDOWN INSPECTION OF # (original Assy. & Serial #).

1.3 Entries in the ISO Books or Covers shall be legible, neat and in ink.

1.3.1 Erasures or obliterations of any entry or callout shall not be made.

1.3.1.1 Entries may generally be voided by printing VOID over the entry and stamping the ends of line for identification.

1.4 Inspection records will not be removed from the ISO Books nor shall the ISO Books be removed from parts, assemblies or inspection area offices without written authorization from Inspection supervision responsible for the clearance or "closeout" of the ISO Book into the Inspection Data and Records Group.

1.4.1 In the event of major damage to the component or assembly during assembly or test, the Inspector shall immediately collect all inspection records and forward them with his report to Inspection supervision for damage survey (according to ROP H-514).

1.4.2 When a test or run is stopped before completion, a squawk should be entered on the squawk sheet and reference squawk number shall be entered in the ISO Book below the operation being performed.

1.4.2.1 The inspector shall request Inspection supervision to obtain pertinent replacement ISO Book Record Sheets and forms from the Process Control Group of Planning to repeat the cancelled operation.

1.5 When Manufacturing has completed operations on the ISO Book and has accomplished the required Shortage Sheets (Form 61-Y); the completed ISO Books shall be audited by the Inspector and the Inspection Leadman. Acceptance of the ISO Book as "complete and accurate" is signified by the stamps of the inspector and inspection leadman in the appropriate blocks inside the front cover (Form R58-C) followed by the signature of the responsible inspection supervisior.

1.5.1 Completed books shall have all items listed on every Sign-Off Record Sheet (Form 611-U or equivalent) properly cleared. This is accomplished when all items are accepted by Inspection or have been transferred to the proper Shortage Sheet (Form 61-Y).

1.5.1.1 The inspector and the inspection leadman shall be responsible for the completeness and the presence of all the required forms and entries in the completed ISO Book.

1.5.1.2 Completed FINAL SHAKEDOWN INSPECTION ISO BOOKS shall be attached to the back cover of its applicable ISO Book when completed. (Not applicable to Neosho.)

1.5.2 The outside front cover (Form R58-C) of any ISO Book shall have a note by inspection supervision or the Process Control Group of Planning stating any disposition of the component (excepting normal acceptance) such as: MORT, SCRAP, TEST ONLY, REBUILD, MODIFY, when the ISO Book is sent to the Inspection Data and Records Group.

1.5.3 The inspection leadman and inspection supervision shall be responsible for the completeness, accuracy and the forwarding to those concerned of the subsequent ISO Books or the forms and reports that are to be inserted into the next assembly book from the ISO Book completed.

1.5.4 Inspection Supervision shall be responsible for the prompt forwarding of completed ISO Books to the Rocketdyne Inspection Data and Records Group Office.

1.5.4.1 ISO Books for REPARABLE GFP from LOGISTICS shall be forwarded after close-out, by Inspection via registered mail or courier to Logistics Engine Clearance for further processing before being forwarded to the Rocketdyne Inspection Data and Records Group Office.

1.5.5 Any engine system or component assembled by Manufacturing, Department 543, and destined for delivery to Engineering, Department 596, and responsible inspection foreman will assure that all applicable records are recapped prior to delivery to Test Inspection, Department 556, Canoga Park.

1.5.5.1 The situation is reversed when Engineering delivers an engine system or component to Manufacturing.

2. INSPECTION SIGN-OFF BOOK COVER*

The Inspection Sign-Off Book Covers (Forms R58-C and R58-C-1) are serialized and are used to identify the Inspection Sign-Off (ISO) Books as the permanent inspection records of certain assembly or test operations performed on particular components and assemblies. The inside of the covers contain blocks to record lists of shortage reports, totals of the discrepancy reports written in the book and blocks for the inspection sign-off of the completed ISO book.

2.1 The Inspection Sign-Off Book Covers, Form R58-C and R58-C-1, are initiated and assembled into the ISO book by the Process Control Group of the Planning Department. The following list of entries on the front cover should be checked for completeness by the inspector. Any discrepancies shall be reported by the inspector to his leadman or supervisor:

(a) ISO Book Serial Number.

(b) Assembly name and number.

(c) Operation, unit number and engine effectivity; with S.O. or S.P. Items (when applicable).

(d) Account, contract, G.O. item or release numbers.

(e) Work done for; and index or hardware number with engine, group or job number (when applicable).

(f) Department where work is to be done, model and Rocketdyne serial number.

2.1.1 Rocketdyne Serial Number: This is entered by the inspector when the serial number is affixed to the component (or by the Process Control Group for designated components).

2.1.2 Customer Serial Number and Installed on Engine Unit Number: These shall be entered by Inspection Records and Data Group at Engine Clearance.

2.1.3 The variable information blocks, Manufacturing routing and operation flow information on the front cover of the ISO book does not apply to Inspection.

2.2 The inside of the front covers (Form R58-C and R58-C-1) have provisions for listing the Shortage Reports (Form 61-Y) for the various components that enter into the component or assembly covered by the ISO Book. The assembly drawing number and the unit or serial number of the required Shortage Reports will be entered by Inspection.

2.2.1 The inspector shall check and 'stamp-off' the assembly and serial or unit number of the component listed against the numbers on the nameplates or the units installed before clearing the ISO Book.

*See illustrations on pages 7 and 8.

2.2.2 The summary SQUAWK blocks shall be completed by the inspector clearing the book by entering the discrepancy report totals (including zeros) from the R 25-U Forms, acceptance stamp his summary block and have his leadman recheck the totals and the book for his acceptance stamp in the LM inspection block.

2.2.3 Inspection supervision shall verify the book as "Accurate and Complete" by signing below the Inspection Blocks at the final close-out of the book.

2.3 The data in the ISO Books is compiled and controlled with Integrated Data Processing Equipment by means of the serial number on the ISO Book cover.

2.3.1 ISO Book covers shall not be transferred by inspection.

2.3.2 When ISO Book covers are damaged or destroyed, the inspector shall immediately notify Inspection supervision and request the Process Control Group of the Planning Department for repair or replacement.

NOTE: Final stores will be responsible for inspection stamping of the Manufacturing Production Control (MPC) Card and the closing out of the ISO Book.

INSPECTION

MPC ____________

SIGN - OFF RECORD

SCHUDULE
I
W
C

RESP. DEPT. ____________

PART NO.		DATE ISSUED CAL. M. DAY	S.O. OR S.P. ITEM NO.
PART NAME		FAB. ACCT. NO. TEST	
OPERATION		CONTRACT G.O.	ITEM OR RELEASE
MODEL NO.	ENG. EFF.	WORK DONE FOR	INDEX HDW. CYC. CPX.
UNIT NO.	ROCKETDYNE SERIAL NO.	TYPE ORDER CODE	AUTH. DOC.
CUSTOMER SERIAL NO.	INSTALLED ON ENGINE OR UNIT NO	INITIAL STORES S / FINAL STORES S	TST / TRT

MANUFACTURING ROUTING AND OPERATION FLOW INFORMATION

ROUTING DEPT.	S	OPERATION	MFG'G L' MAN ACCP'T	SET-UP TIME	RUN TIME	SCH.	SCH.

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ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

This book contains shortage reports for the following assemblies. Unit number on shortage sheet must agree with unit number on installed assembly.

Assembly No.	Unit No.	Insp.	Assembly No.	Unit No.	Insp.

	TOTALS
CUSTOMER SQUAWKS TOTAL NO.	
COMPANY SQUAWKS TOTAL NO.	

INSPECTION

BOOK COMPLETE [ ] INSP [ ] LM

INSPECTION SUPERVISION SIGNATURE

INSPECTION RECORD INFORMATION

1. The Inspection Record cover and its contents constitute a part of the engine or assembly, unit inspection record and are not to be altered except as authorized by Quality Control Operating Procedures or inspection supervision.

2. See Quality Control Operating Procedures regarding:
   A. Standards for Writing Inspection Squawks
   B. Permanent Inspection Records
   C. Cancellation of Inspection Stamp Impressions on Sign-Off, Squawk, Shortage Sheets, Etc.
   D. Parts Removal Procedure.

3. All entries made on a sign-off sheet or the sign-off cover will be made in ink or an indelible pencil. Under no circumstances will the erasure or obliteration of sign-off items, inspection stamp impressions, or approval signatures be permitted.

4. The date of installation must be entered only when an item is signed off.

5. Sign-off sheets must be completed in a neat and legible manner as they are retained as a permanent record.

6. Signing off an item for another employee constitutes a falsification of records which is in violation of a company rule, and is cause for disciplinary action. (Reference Plant Rule Violations, Rule [illegible], Form 62V).

7. Sign-off books, sheets, or any portion thereof will not be removed from a sub-assembly or assembly, unless authorized by inspection supervision.

8. Any changes or revisions to sign-off pages or cover will be made by Planning Department only, and will be clock-stamped by the planner making the change.

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3. INSPECTION SIGN-OFF RECORDS FORM 611-U OR EQUIVALENT*

3.1 This form is used to provide an inspection function over each assembly or test operation in the Inspection Sign-Off Book. Individual records of the inspection, assembly or test by sequence and result, date, mechanic, leadman and inspector can be outlined and recorded as they are accomplished.

3.1.1 An equivalent form may contain sketches with blanks for dimensions for information to be filled in by the mechanic or inspector.

3.2 The Inspection Sign-Off Record Sheets, Form 611-U or equivalent, are initiated by Planning after coordination with Manufacturing and Inspection. They fully cover a series of operations (as a planning ticket) in as detailed a manner as it is deemed necessary. A series of these sheets are bound together by Planning with various other records and issued as a part of the Inspection Sign-Off Book for the several operations (assembly, test and inspection) which are considered necessary to be controlled and recorded during any particular phase of manufacture of components or engines.

3.2.1 ISO Record Sheets that have been voided by error, by an aborted or incomplete test, operation or run are retained in the ISO Book. Additional record sheets are inserted as required for each retest or inspection (by the Process Control Group of Planning at Canoga or Inspection at Neosho) upon request.

3.3 The following information is entered by Planning on each page and shall be verified by the inspector before use.

(a) Page number and total number of pages (in the section or book).

(b) Assembly name and number (as shown on operation drawing).

(c) Rocketdyne Contract or G.O. number (as shown on ISO Book Cover).

(d) Department (where the work is accomplished).

(e) Jig Number (tool number of jig or fixture to be used, if any).

3.3.1 The Unit or Serial Number (as shown on ISO Book Cover) shall be entered by the inspector.

3.4 The following entries are entered by Planning and shall be verified by the inspector during inspection of the operation.

---

*See illustration on page 12.

(a) Sequence (work should be accomplished when practical in numberical sequence).

(b) Drawing station (when required and a zone number for the operation callout appears on the drawing).

(c) Title (of operation or installation shown on drawing, process specification or inspection callout).

(d) When any data is to be entered on the ISO Record Sheet by Manufacturing or Inspection; properly titled and identified blocks must be provided to avoid errors.

3.5 The Date and Mech. entries are made by the Mechanic, as are the dates of the operation and the clock number of the mechanic accomplishing the operation.

3.6 Leadman: The stamp or initials and clock number of the Mechanic's Leadman verifies manufacturing acceptance of the operations.

3.7 Insp.: The inspector shall stamp this column when the operation is acceptable and has been properly signed off by the mechanic and leadman.

3.7.1 If the installation or operation is not accepted by the inspector he shall note the discrepancy in detail on the Inspection Discrepancy and Correction Reports, Form R 25-U, then enter the discrepancy number under REMARKS and acceptance stamp the operation in the Insp. column of the operation.

3.7.1.1 Incomplete operations or tests should be detailed under Remarks and in the DCP Report to avoid duplicate inspection and testing.

3.7.2 The inspector shall report any deviations by the mechanic in the performance of the sequence of operations called for in the Sign-Off Records to Inspection supervision.

3.8 Any discrepancy discovered by the inspector shall be written by the inspector as a discrepancy on Form R 25-U in the ISO Book.

3.8.1 Parts removed or disturbed after an inspection sign-off shall be reported as discrepancies and also noted on Part Removal Form #R 79-Q.

3.8.2 Parts on shortage, or incomplete operations, shall be noted on the Shortage Report Form #61-I.

3.9 Single items that are stamped in error by the inspector, shall be voided by printing "void" across top of stamp (do not obliterate the stamp number). Transfer the information to the remarks section at the bottom of the page with "Stamped in Error" stamp (or print), acceptance stamp and reference action by asterisks.

3.9.1 Voided acceptances caused by part removals, aborted or incomplete test sequences shall be identified by the inspector at the bottom of each page affected.

3.10 All items not available at time of assembly, must be cleared by inspection acceptance or have TRANSFERRED TO SHORTAGE OR HELD UP, stamped across the Mech., Leadman and Insp. blocks. Also, proper entries on the Shortage Report Form 61-Y shall be made before the component is moved to the next station.

3.10.1 Small parts, raw stock, bolts, clamps, etc., on shortage during build-up or test are to be noted as HELD UP and entered as a discrepancy on Form R 25-U. They shall not be entered on the Shortage Report Form 61-Y until closeout of the ISO Book.

3.11 It shall be the responsibility of inspection supervision to coordinate the information and operation callouts in the ISO records with Manufacturing, Engineering and Planning to avoid unnecessary compilation of classified information but still give sufficient direction to the callouts to avoid errors in the operation and the recording of the required information.

INSPECTION SIGN OFF RECORD

Page ____ Of ____	Assem. Name	Assem. No.	Contract	Unit Eff.	Dept.

OPER. No.	Title	Ser. No.	Unit No.	Date	Mech.	Lead Man	Insp.
				X	X	X	X
				X	X	X	X

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Remarks:

Production Verification Rocketdyne Insp. Approval

ROCKETDYNE

4. INSPECTION DISCREPANCY AND CORRECTION RECORDS (FORM R 25-U)*

4.1 This form provides a uniform format for the historical record of the errors or omissions found by Inspection and the Customer Representatives, as well as the corrective actions taken by Manufacturing and Engineering during the assembly and test of rocket engines and components that use Inspection Sign-Off Books; so that the deviations found and the corrective actions taken, may be analyzed for need of further action.

4.2 Inspection Discrepancy and Correction Record Forms (R 25-U) are inserted by the Planning Department in every Inspection Sign-Off Book (ISO) that is used in the assembly or test of rocket engines or components by Rocketdyne and they shall be maintained as a part of the permanent inspection records.

4.2.1 Each Form R 25-U shall be identified by the inspector with the entry of the serial number, drawing number and the model number of the assembly as shown on the cover of the applicable ISO Book.

4.2.2 All deviations from engineering drawings, specifications or inspection procedures shall be entered in sequence by the inspector as discrepancy reports when discovered.

4.2.2.1 INFORMATION discrepancies may be written by the inspector to record pertinent data noted by Inspection, Manufacturing, Test or Engineering personnel.

4.2.3 Additional R 25-U Forms shall be initiated and inserted into the ISO Book by the inspector as required.

4.2.4 The block on the heading of each report entitled DESCRIPTION OF DISCREPANCY AND ACTION TAKEN shall be used by the initiating inspector to indicate the inspection sequence point and station or area of the discrepancies noted, i.e., assembly, 1st E & M, pre-hot-fire, etc.

4.3 Discrepancy entries: Writing of discrepancies on the R 25-U Forms will be the sole responsibility of the inspector. However, a separate Customer Inspection Discrepancy and Correction Record may be initiated for the use of the Customer Representative. (Notations, discrepancies or information discrepancies on Form R 25-U are to be screened by Inspection supervision. Inspection supervision will determine the action to be taken on such information.)

4.3.1 DCP No. or Discrepancy No.: All discrepancies shall be numbered by the inspector starting at one (1) and continuing on in sequence throughout the operations in the ISO Book.

*See illustration on page 17.

4.3.2 Entered by and Date: The inspector writing the discrepancy shall enter the current date and clear impression of his acceptance stamp here.

4.3.3 Part No.: The number that matches the name of the part or assembly against which the discrepancy is written (including any serial number), followed by REF.: (Show operation sequence number as shown in the ISO Book or the assembly drawing and zone numbers.)

4.3.3.1 When the discrepancy has no part number, the work GENERAL and a description of the condition shall be written in this block.

4.3.4 Discrepancy descriptions shall be written by the Inspector to a uniform format in a clear concise manner. The inspection leadman will be responsible for the training of and the reports made by his inspectors.

4.3.4.1 The format of discrepancy descriptions shall be:

TO WHAT (subject)	HAPPENED (verb)	WHAT, WHEN, WHERE (object) (AT)(ON)
Threads	stripped	on 8 boss
Ring	nicked	on AFT bellows
AN521-SR8 on cover	is	AN521-SR6
Lip	damaged	on "O" ring groove
Valve	Failed to open	on test #
B nut at valve end	leaks	on 3000 lb. test
Strut	rides	on 9512-4873 Gear Case

4.3.4.2 All inspection reports of discrepancies should state in quantitative terms what the item should be and what was found as:

3.125 + .0005/ -.0000 DIA is 3.128
.500 DIM of $\frac{1}{4}$ - 28 thrd is .425
35 .25 DIA holes are 33 holes

4.3.5 Discrepancy entries shall be reviewed by the inspection leadman. Repetitive and major discrepancies shall be processed for correction action of Recurrent Discrepancy Forms 88M or 613-N according to Rocketdyne Quality Control Operating Procedure.

4.4 ACTION TAKEN - A clear concise statement of the action taken to clear the discrepancy should be written here - this standard format is suggested:

TO WHAT (subject)	DONE (verb)	WHAT, WHEN, WHERE (object) (AT)(ON)
Part #	Replaced	With Serial #xxxx
B nut	Tightened on Assy. #xxxx	
Damaged screws	Replaced	

QCOP R-8.1 is changed as follows:

4.4.1 ACTION BY MANUFACTURING: Below the broken line, the mechanic will record the action taken, enter his clock number and insert the current date in the "Mech. & Date" block of the "Cleared By" section. When the production leadman approves of the action taken by the mechanic he will stamp the "Leadman & Date" block of the form. If the approval is made on a date other than that recorded by the mechanic, the date of approval will be recorded.

4.4.1.1 If rework is acceptable to inspection, the inspector shall acceptance stamp the "Insp. & Date" block. When the acceptance date differs from the approval or action date, the acceptance date will be recorded.

RJW:is

NEW SUPPLEMENT.

Do not remove QCOP R-8.1.
File between Page 14 and Page 15 of QCOP R-8.1.

Supplement No. 1 clarifies the dates to be entered in the "Cleared By" section of "Inspection Discrepancy and Correction Record," Form R 25-U.

4.4.1 ACTION BY MANUFACTURING: The mechanic will record the action taken (below the broken line), enter his clock number and insert the current date (in the Mech. & Date block of the Cleared by Section). When the Production leadman approves of the action taken by the mechanic he stamps the "Leadman and Date" block of the Form and indicates the date of approval.

4.4.1.1 If rework is acceptable to Inspection, the inspector shall acceptance stamp and date the Inspection and Date block.

4.4.1.2 If the rework is not acceptable to Inspection, the inspector will write a new discrepancy referring to the old discrepancy number in the new DCP No. block and will then clear the original report by noting (Rework unsatisfactory, See DCP #) in the action taken block and stamping the Inspection and Date blocks.

4.4.2 ACTION BY MATERIALS REVIEW: The inspector shall initiate a Quality History Card Form 609-R for the discrepancy and the inspection leadman shall note under action taken, REFERRED TO MATERIALS REVIEW, and enter the serial number of the Form 609-R. (See Sect. 5).

4.4.3 ACTION ACCOMPLISHED

4.4.3.1 Engineering order to clear discrepancies: When an engineering order is issued to accept a reported discrepancy, inspection supervision will record the EO number in the Action Taken block and acceptance stamp and date the Mechanical Leadman and Inspection blocks.

4.4.3.2 When an assembly is moved to another area before the rework can be accomplished, the discrepancy is transcribed by Production and verified by Inspection on the Shortage Report, Form 61-Y, and the Action Taken block marked TRANSFERRED TO SHORTAGE. The inspector will stamp TRANSFERRED in the Mechanic and Leadman blocks and stamp and date the Inspection blocks.

4.4.3.3 A discrepancy that is to be cleared in a later sequence may be transferred to the Shortage Sheet by Manufacturing by noting action as SHORTAGE or HELD UP and stamping TRANSFERRED in the Mechanic and Leadman blocks. The inspector shall verify the transfer before stamping and dating the Inspection blocks.

4.4.4 ACTION NOT REQUIRED

4.4.4.1 A discrepancy (DCP) entered in error shall be cleared by the originating inspector, the inspection supervisor or his leadman by noting ACTION NOT REQUIRED and cause of the error as (Duplicate of DCP #) (Entered in Error) (Wrong Book) (Wrong Drawing) in the Action Taken block and acceptance stamping and dating the Leadman and Inspection blocks. (Caution should be taken not to obliterate the inspection stamp number.)

4.4.4.2 A discrepancy referred to MR for action and with USE AS IS disposition on the MR Form 609-R shall be cleared by the inspector noting such MR action in the Action Taken block and acceptance stamping and dating the Leadman and Inspection blocks.

4.5 Void Inspection Stamps

4.5.1 Void Inspection Stamps will be accomplished in accordance with Paragraph 3.9.

4.6 FINAL ENTRY AT EACH INSPECTION STATION

4.6.1 When the last discrepancy at each inspection station is entered, the inspector shall review the discrepancies written in his area and shall write below the last report: INSPECTION COMPLETE, the name of his station or area and the date. The impression of his inspection stamp will verify the completeness of the reports and the action taken.

4.7 CUSTOMER INSPECTION DISCREPANCY AND CORRECTION RECORDS

4.7.1 The customer Quality Control Representative may elect to use the same format for his discrepancy reports to assure uniformity of records and procedures.

4.7.2 Customer DCP records, if used, will be placed by Inspection under the front cover of the Inspection Sign-Off Book.

4.7.3 Customer Quality Control representative will write TO BE RESUBMITTED, in the block entitled DESCRIPTION OF DISCREPANCY and ACTION TAKEN, if he does not delegate the acceptance of the corrective action taken to the inspection supervisor to Section 4.4 of this procedure.

4.7.?.1 Discrepancies to be resubmitted will be coordinated by inspection supervision or inspection leadman with specific inspection instructions.

4.8 Any information squawks or entries made in error are not considered as countable squawks against the assembly and fabrication of a component or engine.

INSPECTION DISCREPANCY AND CORRECTION RECORD

MAKE ENTRY CLEAR AND CONCISE, USE INK

Dwg. No.

DCP No.	Ent'd By & Date	DESCRIPTION OF DISCREPANCY AND ACTION TAKEN	CLEARED BY Mech. & Date	Lead-man & Date	Insp. & Date
		PART NO.			
ACTION TAKEN					
		PART NO.			
ACTION TAKEN					
		PART NO.			
ACTION TAKEN					
		PART NO.			
ACTION TAKEN					
		PART NO.			
ACTION TAKEN					

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Form R 25-U Rev. 12-1

NOTES:

5. MATERIALS REVIEW ACTION (FORM 609-R) IN THE INSPECTION SIGN-OFF BOOK*

5.1 This form is supplemental to the Inspection Discrepancy and Correction Records Form R 25-U and is used in conjunction with the ISO Book to record the discrepancies noted by Inspection which cannot be accepted or whose rework to the required specifications cannot be cleared by the inspector. This form also provides a uniform manner of recording the instructions of the materials review engineer and the inspection supervisor to assist Manufacturing and Inspection in the correction of the immediate discrepancy as well as providing a historical record of materials review action as a basis for analysis and corrective action on repetitive defects.

5.2 When a discrepancy (R 25-U or Structural Approval or Materials Review Form 60-W) from an Inspection Sign-Off Book entry is to be referred to Materials Review for action, the inspector shall initiate a Quality History Card, (QHC) Form 609-R, according to QCOP R-4.4 and R-4.9 except for the following instructions:

5.2.1 Part Number: (Item #2 on the 609-R Form) The part number of the part or assembly requiring ISD or MR action and referenced in the Form R 25-U or 60-W will be entered.

5.2.2 Name - Item 3: Enter the name of the major assembly from the face of the Sign-Off Book, for example, Turbo Pump, (T/P), Thrust Chamber, (T/C), Engine, or Gas Generator, (G.G.).

5.2.3 Unit or Serial No. - Item 4: Enter the unit or serial number of the major assembly from the face of the Sign-Off Book.

5.2.4 The discrepancy number will be referenced on the back of the QHC in item #39.

5.2.5 Discrepancy Detail - Item 40: The discrepancy will be transferred by the inspector from the R 25-U to the reverse side of the QHC (Form 609-R). The serial number of the Form 609-R will be entered on the R 25-U as a cross reference.

5.3 The discrepancy in R 25-U or 60-W and the Form 609-R shall be referred to inspection supervision for preliminary analysis into one of the following categories;

(a) for items that may be reworked using a method of the Standard Repair Manual.

(b) for items requiring normal rework for acceptance.

(c) for items that will require MR action for disposition.

*See illustrations on pages 20 and 21.

The discrepancy shall be left open until Materials Review or ISD action has been accomplished and accepted.

5.4 Dispositions requiring MR Engineers approval: MR engineer will indicate disposition by signing item #40 but his stamp is placed in column #35 and checking disposition type #4 or #6 as applicable in item #38.

5.5 The entries in items 20 through 26 by the production leadman will be required in accordance with QCOP R-1.17, paragraph 3.2 through 3.3, when the ISD or MR disposition is rework.

5.6 Disposition on 609-R Form shall be written only by authorized Inspection or Material Review personnel. For further information on the 609-R card, see QCOP R-4.1 and R-4.4.

5.7 Erasures shall not be made; corrections shall be made by the Inspector by striking out the error with a single line and stamping the entry.

5.8 After all disposition entries have been accomplished and transferred to the 60-W, the 609-R card will be removed from the ISO book and placed in the Quality Assurance pick-up box. (Customer surveillance of 609-R cards is as requested)

FORM 609-R Rev. 10-56

39. Oper. No. 40. DISCREPANCY DETAIL & REWORK INSTRUCTIONS

41. CORRECTIVE ACTION REQUIRED ☐ Signed ______ Title

42. CORRECTIVE ACTION

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Effective on Unit No. or Date: PRODUCTION SUPERVISION:

DEPT. OR SUPPLIER

ROCKETDYNE
QUALITY HISTORY CARD

PART NUMBER

1. Dept. or Supplier
2. Part or Assy. Number
3. Name
4. Unit or Serial No.
5. G. O. No.
6. Release or P.O.
7. Qty. Subm.
8. Insp. Stamp
9. Date
10. ☐ Prog. Insp. ☐ Final Insp. ☐ Rwk. Insp. ☐ P.R.R. No. ____
11. Cause Code
12. Discp. Code
13. Disp. Type
14. Hours
15. Inc.
16. OK
17. Rwk.
18. Scrap
19. Qty. Discrep.
20. Section or Station
21. Oper. No.
22. Machine No.
23. Mech. or Welder
24. Inches of Weld-Braze
25. Hours
26. Leadman Stamp
27. Qty. Disc.
28. Cause Code
29. Disc. Code
30. Inc.

Disposition: 31. OK 32. RW 33. Scrap

BY: 34. Insp. 35. M.R. 36 Eng

37. Disp. Type

38. Type of Disposition: Check one ☐ 1. I.D. Rwk. ☐ 2. I.S.D. ☐ 3. M.R. Insp. ☐ 4. M.R. Engineer

☐ 5. Repair Manual Sect. ____ Page ____ 23-H-I No. ____

☐ 6. Original ☐ 7. Re-use

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NOTES:

6. INSPECTION HOT-FIRE TIME SHEET (FORM 615-R)

6.1 The Form 615-R, Inspection Hot-Fire Time Sheet is a part of each Inspection Sign-Off Book requiring the recording of hot-firing time for engines and applicable components. This information is retained as a permanent inspection and historical record utilized for quality and reliability performance analyses.

6.2 The Inspection Hot-Fire Time Sheet is designed for the purpose of recording, accumulating and controlling allowable hot-fire time on engines and components.

6.3 The Inspection Hot-Fire Time Sheets are inserted in the build-up ISO Books by the Planning Process Control Group with Inspection responsible for the following entries:

6.3.1 Engine Model No.______: Enter the model number applicable to the engine. Occasions do arise when Plan of Action letters stipulate changes to engine models. Consequently, it is advisable for the inspector to check with the Planning representative in the area to obtain the necessary information.

6.3.2 Component Name______: Enter the name of the component, i.e., Thrust Chamber, Turbopump, Gas Generator, Turbine, etc.

6.3.3 Serial______: (Upper Right Corner) Enter the Rocketdyne serial number of the component. If an engine is being hot-fired the unit number, taken from the top of the ISO Book, is entered on this line.

6.3.4 Component Name & Part Number - Enter the applicable component name and part number in this column. When an engine is being hot-fired list the engine model and number and the applicable component names and part numbers that require a hot-fire time log.

6.3.5 Serial Number - Enter the component serial number. When the engine is listed the unit number taken from the top of the ISO Book will be entered.

6.3.6 Accumulated Time Green Run - This column applies to applicable components. Entries for "Green Run Firings," for a component, is the responsibility of Inspection at the Propulsion Field Laboratory (PFL-Santa Susana). Entries for "Accumulated Time Green Run" for components when an engine is to be hot-fired is the responsibility of inspection in Final Assembly. This information is obtained from the Assembly Identification-History Record Card (Form R 93-H-1 "Blue History Card").

6.3.6.1 Whenever an engine is to be released for hot-fire, inspection personnel of Final Assembly will determine which components may be removed from the engine system because of the allowable hot-fire life cycle of the component.

6.3.7 Ins. (Inspection): The inspector will verify the entry made on each line by placing an inspection acceptance stamp in the appropriate block.

6.3.7.1 Wherever "Ins." columns appear on the form an inspector's acceptance stamp is required, applicable only to the entry in the appropriate column.

6.3.8 Run Number - Into the first block will be entered the run number. This number is obtained from Engineering and is entered by inspection (PFL) for each new hot-fire start. Only one run number to a column. The time, applicable to a run number is entered in the blocks below. Actual run time will be recorded.

6.3.9 Total Accumulated Time (Under "Engine" Block) - In this column the inspector (PFL) will enter the sum total of all hot-fire runs applicable to each component. The sum total of the engine hot-fire time will also be entered in this column.

6.3.10 Date Insp. - The responsible inspector will enter the date and inspection acceptance stamp verifying the entries.

6.3.11 Remarks - In this colum pertinent information will be entered such as, component replaced by (give serial number), see "Replacement Record," etc. The inspector will apply his stamp at the end of each entry.

6.4 In the "Replacement Recording" portion of the form will be the name, part number and serial number, etc. of the component replacing the component that had to be removed.

6.4.1 If no run time has been accumulated on the component, the digit "0" will be entered in the "Accum. Time Gr. Run" column.

ENGINE MODEL NO. ____________

COMPONENT NAME ____________

INSPECTION HOT FIRE TIME SHEET

SERIAL ____________

COMPONENT NAME & PART NUMBER	SERIAL NUMBER	ACCUM. TIME GR. RUNS	INS	RECORD ACTUAL RUN TIME: RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	ENGINE: TOTAL ACCUM. TIME	DATE INSP.	REMARKS

REPLACEMENT RECORDING

COMPONENT NAME & PART NUMBER	SERIAL NUMBER	ACCUM. TIME GR. RUNS	INS	RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	RUN NUMBER	INS	TOTAL ACCUM. TIME	DATE INSP.	REMARKS

FORM [illegible]

NOTES:

7. PART REMOVAL RECORD FORM R 79-Q OF THE INSPECTION SIGN-OFF BOOK*

7.1 The Form R 79-Q is used by Manufacturing and Inspection to assure the acceptable replacement, operation or test of any or all items whose installation has been previously inspected and they disturbed in the subsequent removal or reinstallation of any part on those assemblies using Inspection Sign-Off Books as a history record.

7.1.1 The accuracy and the completeness of the Part Removal Record shall be the sole responsibility of Inspection and shall be maintained in the Inspection Sign-Off Book.

7.2 When any part is to be removed or an adjustment is to be disturbed by any operations after their inspection sign-off in the ISO Book, the mechanic will make the appropriate entry on the Part Removal Record (Form R 79-Q).

7.2.1 The mechanic should enter the necessary information on the Form R 79-Q and secure the approval of the inspector to make the removal before the removals are made. The Inspector is responsible for the completeness and the accuracy of all entries on Form R 79-Q and for giving authorization for each removal.

7.2.2 The following information is to be entered on the Form R 79-Q by the mechanic prior to removal:

(a) DEPARTMENT: The area where the removal records started.

(b) ASSEMBLY NAME, ASSEMBLY NO., SERIAL NO.: These identify the assembly from which the parts are to be removed and should be as shown on the cover of the ISO Book.

(c) ITEM: Name and number for each part removed (as shown on the drawing).

(d) REASON FOR REMOVAL: EO number, change letter, Discrepancy #___ or to Remove #___.

(e) EMP. NO.: The mechanics clock number.

(f) LOCATION: Station where removal is to be made: (1st E & M, CP) or (TRE-2SS).

(g) PRR #: From LH corner of Parts Replacement Request, Form R-17A (if applicable).

7.3 When removal authorization is requested the Inspector will;

(a) see that the Part Removal Record sheet is inserted securely in the ISO Book,

*See illustration on page 30.

(b) determine that the removal is necessary,

(c) list Discrepancies and enter the part number of any other disturbed assemblies and functional tests if required,

(d) record the entries listed below and verify the entries recorded by Manufacturing.

7.3.1 OK TO REMOVE: The Inspector's acceptance stamp in the Co. Insp. block will verify all previous information (on the date stamped) and authorize the removal. Customer Inspection stamp will be secured by the Inspector (if required).

7.3.2 SERIAL NUMBER, ORIGINAL: Inspection to verify or record NONE (if applicable to the removed items).

7.3.3 CAUSE for the malfunction or results of test shall be entered by Inspection.

7.3.4 TR # is the (FCDR #) Failure and Consumption Data Reporting number (Form 610-C-60) the Inspector shall enter NONE if not required.

7.3.5 INSPECTION: Inspector will verify the TR # entry or the Failure & Consumption Data Report (FCDR #___) with his stamp.

7.4 OK TO INSTALL: When a part is to be reinstalled or a new part installed the Inspector will:

(a) Verify that the replacement part is acceptable.

(b) Be sure that the area is free of obstructions.

(c) Determine that all installation preparations are as shown in the ISO Book

(d) Be certain that all discrepancy entries on the "squawk sheet" are cleared and the required functional tests have been performed to assure proper installation and operation in the entire area.

(e) Submit to Customer Inspection for acceptance stamp, if required.

(f) Signify inspection approval by stamping the "Co. Inspection" block on the form with his acceptance stamp.

7.4.1 SERIAL NO. NEW: When Manufacturing enters the serial number of the item installed the Inspector shall verify (or record NONE if applicable).

7.4.2 INSTALLATION OK: When the mechanic enters his clock number, the Inspector will acceptance stamp and date the INSPECTION block and submit the record to the Customer Inspector, if required, for his stamp if the item has been installed acceptably.

7.4.2.1 When INSTALLATION is incomplete the entry shall be stamped "Transferred to Shortage" or "Transferred to Held Up" and inspection stamped to verify that the item will not be reinstalled in the area. Or "Transferred to Sign-Off Book" (when extensive dis-assembly is required and the pertinent section of the Sign-Off Book is added to cover the rework operations required). The Inspector shall cross-check all transfers into the ISO Book and Shortage Report (Form 61-I).

7.4.3 OPERATION OK: When the mechanic enters his clock number, the Inspector shall acceptance stamp and date these blocks and submit the record for the customer inspection stamp (if required). If inapplicable the Inspector will stamp NOT REQUIRED and verify this with the inspection acceptance stamp.

7.5 The Inspector shall give particular attention to adjacent parts or assemblies that may have been disturbed by the removal, reinstallation or adjustment of the items recorded. The Inspector will be responsible for writing the required discrepancy to assure the acceptable replacement, adjustment, operation or test of any or all disturbed items.

R-3729P

ROCKETDYNE

PART REMOVAL RECORD

DEPT.__________ ASSEM. NAME __________ ASSEM. NO. __________ SERIAL NO. __________ MODEL NO. __________

ITEM				OK TO REMOVE			SERIAL NO.	OK TO INSTALL			SERIAL NO.	INSTALLATION OK				OPERATION OK			
PART NUMBER	PART NAME	REASON FOR REMOVAL	EMP. NO.	CO. INSP.	DATE	CUST. INSP.	ORIG.	CO. INSP.	DATE	CUST. INSP.	NEW	CO. MECH.	INSP.	DATE	CUST. INSP.	MECH.	CO. INSP.	DATE	CUST. INSP.
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			
LOCATION		PRR #		CAUSE															
													TR #			INSPECTION			

Form R 79-Q Rev. 1-58

8. SHORTAGE REPORT (Form 61-Y)*

8.1 The Shortage Report (Form 61-Y Rev. 3-56) is used only for components that are assembled by an Inspection Sign-Off (ISO) Book. They are used to record part shortages, items whose assembly is held up due to shortages, operations not checked due to shortages, to record the fulfillment of shortages out of sequence in the department and to collect and transfer a record of the shortages so that they may be accomplished and recorded in other departments.

8.2 Inspection Responsibilities:

8.2.1 Inspection will be responsible for checking, verification and close-out of Shortage Reports.

8.2.2 Inspection will verify that a Shortage Report is in each Sign-Off Book and that a Shortage Report is placed in a shipping envelope and attached to the assembly at the time of sign-off.

8.3 The following information is recorded in the Shortage Report by Manufacturing Personnel and verified by Inspection.

(a) ELEC., MECH., ORIG., DUP.: These will be checked to indicate the nature of the entry and whether the Shortage Report is an original or duplicate copy.

(b) ASSEMBLY NAME: As shown on the applicable drawing.

(c) ASSEMBLY NUMBER: The assembly on which the parts are short or held up.

(d) L.H., R.H., UPPER, LOWER (IF APPLICABLE): As shown on the assembly drawing.

(e) DEPARTMENT NUMBER: The department initiating the Shortage Report.

(f) SHIP OR UNIT NUMBER: The engine or unit sequence number as shown on the cover of the Sign-Off Book.

(g) CONTRACT NO.: As shown on the Sign-Off Book.

(h) SERIAL NUMBER: The company serial number of the assembly.

(i) DATE: Shortage Report form origination date.

(j) SHORTAGES: (Check one): Indicate whether the part is an ACTUAL (missing) shortage or HELD UP item (unaccomplished).

---

*See illustration on page 34.

NOTE: An actual shortage may necessitate entering an item or an operation on the shortage report as a "held up" item because its installation or operation may not be completed until the shortage is installed.

(k) SHORTAGES, INSPEC. VERIFY: Inspection Acceptance Stamp in this block verifies that the item is "short" or "held up" and that it has been properly transferred from the Inspection Discrepancy and Correction Record (Form R 25-U).

(l) QUANTITY: The quantity of parts short or held up.

(m) PART NUMBER: Of the shortage or held up item as shown on the assembly drawing. (When parts are called out on assembly drawings other than the assembly number named in the report - reference the assembly drawing number which calls out the part).

(n) COMPLETE PART NAME: As shown on the applicable assembly drawing.

8.3.1 When the shortage items are installed for all entries on the Shortage Report (prior to transferring the assembly to the next department), the Inspection Leadman or Inspection Supervisor will close out the report by placing the date and his signature and stamp on the line immediately below the last shortage or held up entry.

8.3.2 Entries for those shortages transferred from the R 25-U form or other shortage reports shall have "Transfer to Shortage" or "Held Up" stamps applied; the Inspector shall place a single inspection stamp in the right hand inspection column on both the Discrepancy Report and Shortage Sheets on the line with the stamp and referring entry.

8.4 Upon completion of assembly build-up, the ISO Books shall be audited by Manufacturing and Inspection.

8.4.1 If any items remain unaccomplished, these items shall be recapped to a Shortage Report (Form 61-Y) on a single form with two spaces left for action taken and verified by the Inspector. This single form shall be inserted into first subsequent ISO Book by Inspection.

8.4.2 After transfer of the assembly to the next department, the following entries are recorded on the Shortage Report upon completion of installation of "short" or "held up" items.

8.4.2.1 Date: The date that the shortage or held up item is installed.

8.4.2.2 Mech.: The clock number of the mechanic making the installation and recording the action taken.

8.4.2.3 L.M.: The responsible Manufacturing Leadman's stamp.

8.4.2.4 Insp.: The Inspection acceptance stamp in this column verifies that the installation is acceptable and the Date, Mech. and L.M. columns are completed.

8.4.3 During first E & M hot-fire and second E & M checkout, if any additional shortages or held up items develop, they shall be recorded by Manufacturing on the same 61-Y Form, inserted in this book by Final Checkout Inspection and verified by Inspection.

8.4.4 At completion of engine acceptance by the customer, the E & M Checkout and Hot-Fire Book shall be audited and if any shortages or held up items cannot be cleared, they will be recapped by Manufacturing and verified by Inspection on a single Form 61-Y. This single form shall be placed by Inspection in a shipping envelope and attached to the engine for processing into shipping.

8.5 At the closeout of the Inspection Sign-Off Book and CVR Book from any station or area and no shortage or held up items are recorded on a Shortage Report, the Inspector will close out the report by placing the word "NONE", the date, his signature and his stamp on the first line.

SHORTAGE REPORT

☐ ELEC. ☐ MECH. ☐ ORIG. ☐ DUP.

ASSEMBLY NAME	ASSEMBLY NO.	L.H.	R.H.	UPPER	LOWER

DEPARTMENT NO.	SHIP OR UNIT NO.	CONTRACT NO.	SERIAL NO.	DATE

SHORTAGES CHECK ONE ACTUAL	HELD UP	INSP. VERI.	QUAN.	PART NUMBER	COMPLETE PART NAME	DATE	MECH.	L.M.	INSP.

This sheet is to be prepared in duplicate by the production department. All entries will be made with pen, indelible pencil or with a typewriter. Responsible production personnel will place a check mark (√) in the applicable column to indicate whether the shortage is actual or held up. Inspection will add the original and/or the duplicate shortage sheets to the sign-off book and verify correct entries by placing an inspection stamp impression in the applicable block.

9. SERIALIZATION RECORDS IN ISO BOOK*

9.1 The Serialization Record Sheets (Form 604-N-2) are used in the Inspection Sign-Off Books to record the serial numbers and installation dates of certain selected components installed in the assembly. These records are retained as permanent inspection and historical records and are utilized in quality and reliability performance analyses of engines and components.

9.2 The Serialization Record Sheets (Form 604-N-2) are initiated, inserted and maintained to current status in the Inspection Sign-Off Book by the Process Control Group of Rocketdyne Planning Department.

9.2.1 The Planning Department enters the part name and number on the heading of each sheet.

9.2.1.1 These entries shall be checked by the Inspector and should be identical to those on the front of the cover of the ISO Book.

9.2.1.2 The Inspector shall enter and verify the serial number of the assembly from the front cover of the ISO Book (as assigned).

9.2.2 The Planning Department will list the Part Numbers and Names of serialized assemblies or parts that are to be assembled in the component.

9.2.2.1 These entries shall be checked by the Inspector to the applicable drawings, sign-off records and the actual installation.

9.2.2.2 The Inspector shall enter the serial numbers (in the ORIG. S/N Blocks) of the parts listed from the actual installation, dating the DATE blocks and acceptance stamping the INSP. block to show verification. (Use the Rocketdyne Serial Numbers when available)

9.2.3 The Inspector shall make corrections or changes to the part names or numbers entered on the Serialization Record and shall notify the Inspection Leadman or Inspection Supervision to request immediate correction by Planning.

9.2.4 The accomplishment of the Replacement Data section of the Serialization Record is the responsibility of the Inspector and shall be coordinated with his acceptance of the Part Removal Record (Form 79-Q) of the ISO Book.

9.2.4.1 The Inspector shall enter the serial number, date and his acceptance stamp in the appropriate line and columns to record the replacement of any item listed on the Serialization Record.

*See illustration on page 37.

9.2.4.2 When an item has been replaced and its replacement date section is filled, the part number and name shall be transferred to a vacant line and the new (replacement) serial number entered in the ORIG..S/N with the installation date entered with the acceptance stamp of the inspector in the Date and Insp. blocks. The Inspector shall then draw a line through the Final Verification blocks of the original line of entries.

9.2.4.3 When the part number of an item on the Serialization Record is changed at a replacement (due to EO or drawing change) (For information only), the Inspection Leadman or Inspection Supervision shall be notified to request the Planning Department to make an immediate correction of the Serialization Record by an entry of the new number on a vacant line.

9.2.4.3.1 The Inspector shall close out the previous line of entries by drawing a line through remaining Replacement Data blocks and the final verification blocks, then entering the serial number of the newly installed part in the new line under ORIG. S/N with the date and his acceptance stamp.

9.2.5 Final verification entries are made at the closeout of the Inspection Sign-Off Book to verify the presence of the part by part number and serial number on the assembly (as written).

9.2.5.1 Transfer of the Final Engine Assembly Serialization Records or information to the ISO Book for next assembly or test shall be by the Inspector or the Inspection Leadman at the closeout of the book or by the Inspection Records and Data Group after Final Verification.

9.2.6 Prior to closeout of the ISO Book the Serialization Records sheets shall not be removed or transferred from the Book without the written consent of the Inspection Supervisor responsible for the closeout approval of the ISO Book.

FORM 604-N-2 Rev. 8/58

SERIALIZATION RECORDS

S/N ____________

PART NO. ____________________ PART NAME ____________________

PART NUMBER	PART NAME	ORIG. S/N	DATE	INSP.	REPLACEMENT DATA						FINAL VERIFICATION	
					S/N	DATE	INSP.	S/N	DATE	INSP.	DATE	INSP.

R-5729P

NOTES:

10. ORIFICE AND RESTRICTOR RECORD

10.1 The Orifice and Restrictor Record (Form 604-N-1) is used as the permanent inspection record of the sizes, locations and part numbers of those orifices and restrictors in rocket engine systems. During the various trials and tests that are made to achieve comliance with specific detailed Engineering parameters, assembly and test personnel may change orifices and restrictors.

The only orifice and restrictor changes made on the rocket engine are those required by drawing and the final size determined by rocket engine calibration testing. All other changes will require an Engineering Order.

All measurable orifices shall be inspected at the time of installation and recorded on the orifice log of the ISO Book.

All orifice parts will be adequately sealed and verified by inspection upon installation in the rocket engine. If seals are broken by anyone other than an inspector, the orifice will be remeasured, reidentified if required and resealed. If subsequent removal of an orifice is necessary for recalibration or any other reason, the above requirements shall apply relative to reinstallation and recording. A cross reference will be made of ISO Book Orifice Log, Orifice Installation and Engine Data Log orifice size callout at time of 2nd E & M prior to delivery.

10.2 Rocket Engine Assembly prior to Acceptance Test

10.2.1 Orifice parts to be installed in the rocket engine will be identified with the part number, inspection acceptance stamp and packaged in a sealed bag. The sealed bag will be appropriately identified to preclude it being opened.

10.2.2 Recording all orifice changes prior to acceptance test will be accomplished by entries in the Part Removal Record Form R 79-Q and not the Orifice Log Sheet in the ISO Book.

10.3 The Orifice Record sheets are initiated and inserted in the first build-up ISO Book by the Planning Process Control Group with the following entries to be verified by the inspector.

10.3.1 R/E_____: This is the assembly number as shown on cover of the ISO Book.

10.3.2 R/E Ser. No.____: This is for the series group and model number as shown on the cover of the ISO Book.

10.3.3 Page___of___: This identifies the total number of Orifice Record Sheets that should be in the book and their sequence.

10.3.4 Rev. Date____: This is the last change date by Process Control Group of the entries.

10.3.5 Part Number & Name: These blocks are used to record the system (Fuel or Lox) and whether the part is an Orifice or a Restrictor Plate, followed by the part number of the item.

10.3.6 Location: These are detailed descriptions of the unit systems and the items between which the Orifices or Restrictor Plates are installed.

10.4 The balance of the entries on the Orifice Record sheets shall be made and verified by the Inspectors.

10.4.1 Contract______: The contract number as shown on the ISO Book Cover.

10.4.2 R/E Ser. No.______: The serial number as shown on the ISO Book cover and must be compatible with the series group numbers shown by Planning.

10.5 ASSEMBLY AREA DATE_______: The area identification and the date of the first installation inspection.

10.5.1 Size: These shall be entered by the Inspector from the actual, or equivalent, verified size of the opening on the appropriate item shown under part number, number and location.

10.5.2 Inspection: The inspector's stamp is placed here to verify the acceptance of the tag and Orifice installation.

10.6 Run Number: When an Orifice or Plate is changed, the inspector shall note the run number in the space at the heading of the column and enter the new size number in the appropriate size block or blocks with his inspection stamp to verify the physical check of the changes in items and identification tags.

10.6.1 When the part number of a replaced orifice is different than the original, the inspector shall note "See Removal Sheet" in the run number block.

10.6.2 When more than seven (7) recordings of runs are required, the inspector making the verification shall enter the legend, SEE BELOW, or SEE PAGE NO.____, in the final orifice installation SIZE AND PART NO. blocks and insert his stamp.

10.6.2.1 The inspector shall then transfer the required ENTRIES in the "Part Number and Name" and the location blocks to the new location.

10.6.2.2 When a new page is required, the inspector shall transfer the entries on the headings and add the word continued after the page number.

10.7 During and subsequent to acceptance test, all variable orifice changes will be accomplished by entries in the Part Removal Record. Final orifice installation entries shall be the responsibility of the inspector at final assembly, after hot-fire and immediately prior to closeout of the ISO Book. He shall enter the following:

10.7.1 Date____: Date of final installation verification by the inspector.

10.7.2 Size: Part No.: These entries must be made by the inspector after physical check of the tags on internal orifices and plate markings and must correspond to the size and part number shown in the last run number entry.

10.7.2.1 Tags and markings accepted by the inspector shall be acceptance stamped by the inspector in the FINAL column.

10.7.2.2 After installation of internal orifices, a metal tag will be attached on or adjacent to the orifice and will be identified with part number, orifice size and an inspection stamp.

10.7.2.3 The orifices listed on the Data Log Sheet in the Rocket Engine Log Book will be checked for accurate log book entry against the orifice installed on the engine. This inspection will be made prior to inspection acceptance of Form DD250.

10.8 The orifice and restrictor record as a historical record is transferred by the inspection and the inspection leadman at the "closeout" of each ISO Book until final "closeout" before engine clearance. It is left in the Final Assembly ISO Book when "closed out" into engine clearance.

10.8.1 As each orifice and restrictor is critically important to the operation of the engine, extreme care must be exercised by the inspectors and inspection leadmen in their verification and acceptance of the part number and orifice sizes listed which may be different than those on the initial assembly.

10.9 Overhaul Engines and engines in Logistics will be treated as post acceptance test as outlined in paragraphs 10.7 and 10.8.

10.10 Purchased Material Inspection Supervision, Department 558, are responsible for the spot check and 100% check of all measurable orifices in stock and that all measurable orifices will be reinspected at the time of shipment as kits or spares.

ORIFICE & RESTRICTOR RECORD

R E ____ ____ CONTRACT ______

R E SER NO ____________________

PAGE ____ OF ______

REV DATE ________________

PART NUMBER & NAME	LOCATION	ASSEM AREA	RUN =	RUN =	RUN =	RUN =	RUN =	RUN =	FINAL ORIFICE INSTALLATION SHOW SIZE AND FINAL PART NUMBER	
		DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE METAL TAG VERIFICATION	
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO
		SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	SIZE	PART NO
		INSP	INSP	INSP	INSP	INSP	INSP	INSP	INSP	PART NO

FORM 604-N-1 REV. 10-57

11. THRUST CHAMBER LEAK CHECK AND REPAIR LOG (FORM 607-N)*

Thrust Chamber Leak Check and Repair Logs (Form 607-N) are used in the ISO Books as a graphic and chronological record of the Thrust Chamber Leak Checks and Repairs.

This Form is used for tubular wall thrust chambers and is a contractual requirement; it is supplementary to the Inspection Sign-Off (ISO) Records, Inspection Discrepancy and Correction Record (R 25-U) and Materials Review Action Reports on Quality History Cards (Form 609-R).

11.1 Initiation and insertion of 607-N Forms into the Inspection Sign-Off Books for the body assembly of the thrust chambers are accomplished by the Process Control group of the Planning Department and verified by the Inspectors.

11.1.1 The proper entries, follow-up, and additional insertion of the forms into the sign-off books, traveling with the thrust chamber or the engine, will be the responsibility of Inspection. Additional forms can be obtained from the Process Control Group of the Planning Department.

11.2 Procedure

Form 607-N has two (2) thrust chamber views and a sign-off section to describe the discrepancies and corrective actions. View A and B will aid in establishing the location of each discrepancy.

11.2.1 Initial entries on each Form 607-N shall be entered by the using concerned Inspectors. These entries include the Part Number, Thrust Chamber Serial Number and Engine Serial Number from the assembly and the Inspection Sign-Off Book Cover.

11.2.1.1 Pages shall be numbered in sequence starting with the Number 1.

11.2.2 During fabrication of the thrust chamber, specified pressure checks will be witnessed and the results entered on Form 607-N by the Inspector in the "Discrepancies" column in the following manner.

11.2.2.1 Discrepancies will be numerically recorded in sequence by entering the appropriate number in the upper left corner block of each section.

11.2.2.2 The Inspector shall apply his stamp in the blocked area between "insp." and "date."

*See illustration on page 46.

11.2.2.3 DATE: Enter the date inspection is accomplished.

11.2.2.4 NO DEFECTS: The Inspector's stamp is applied here when there are "No Defects."

11.2.2.5 DEPT.: The Department Number where the thrust chamber test has been made shall be entered here.

11.2.2.6 "CC" BLOCK: When a leak of 400 CC or less is recorded at test, enter the amount (in cubic centimeters).

11.2.2.7 GAL.: Enter the amount of leakage (if any) in gallons (e.g. 2/10).

11.2.2.8 INSIDE OR OUTSIDE: Check (✓) the applicable block indicating the side discrepancy is located.

11.2.2.9 LBS.: Enter the amount of pressure applied (1000 lb. or 30 lb.) which signifies the type of test performed.

11.2.2.10 Discrepancies recorded in the body of the form shall read: "Leaks at (___) o'clock station inside, ref. DCP #xx."

11.2.2.11 When no discrepancy exists the word NONE is entered and the Inspector shall apply his inspection stamp to both sides of the word.

11.2.3 Severity of the damage to the thrust chamber assembly is assessed by the Inspector or Inspection Supervision to determine the level of repairs for inspection acceptance.

11.2.3.1 Repair discrepancies recorded in the 607-N by the Inspector shall also be recorded on the Quality History Card Form 609-R and the Form R 25-U.

11.2.3.2 The Standard Repair Manual shall be consulted for the authorized level of repair and test.

11.2.4 Applicable entries of accomplished repairs will be recorded in the "Corrective Action" column. Completion and inspection acceptance of corrective action will require the following entries:

11.2.4.1 The Mechanic's Clock Number and the date the repair was completed.

11.2.4.2 The Mechanic Leadman will apply his stamp and enter the date in the applicable blocks.

11.2.4.3 The Inspector will apply his stamp and enter the date upon accepting repairs or verifying pressure tests.

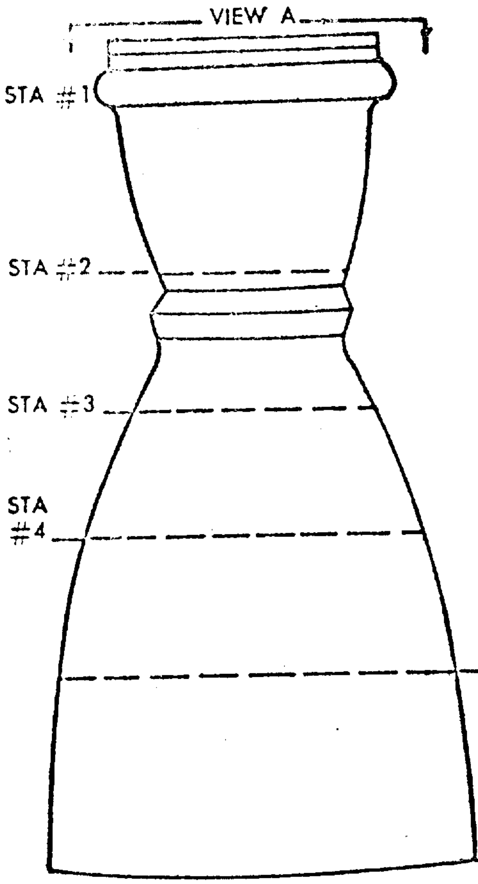
11.2.4.4 Follow-up for required signatures and inspection acceptance stamps clearing the discrepancy in the Materials Review Action Forms, will be made in accordance with applicable Quality Control Operating Procedures.

11.2.5 Upon completion of acceptance inspection of the fabrication of the thrust chamber body assembly, the Inspector will duplicate the Form 607-N and together with a 93H-1, Parts Identification Tag, attached to the thrust chamber body assembly, route the unit to final build-up and assembly. The thrust chamber body assembly sign-off book is forwarded to the concerned Engine Clearance Group for composite information and completion of engine records.

11.2.6 A composite report of all repairs listed on Form 607-N shall be accomplished by the concerned Engine Clearance Group.

ROCKETDYNE

THRUST CHAMBER LEAK CHECK AND REPAIR LOG



VIEW B

PAGE _____ OF _____

PART NUMBER ____________

THRUST CHAMBER S/N ____________

ENGINE SERIAL NUMBER ____________

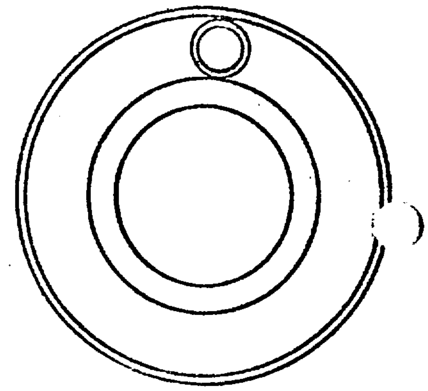
INSTRUCTIONS

In View "A" locate the leak and/or repair clockwise by the use of an asterisk (*) along with a number indicating whether it is the 1st, 2nd, defect, etc.

In View "B" locate the leak and/or repair in the same manner using the stations this time.

NOTE: ℄ of Manifold Inlet will be utilized as 12 o'clock.

12 O'clock



VIEW A

ALL ENTRIES MUST BE PRINTED IN INK

DISCREPANCIES								CORRECTIVE ACTION			
	INSP.		DATE		NO DEFECTS		DEPT.		MECH.		DATE
____ CC	____ GAL.	INSIDE		OUTSIDE		LBS.			LD. MAN		DATE
									INSP.		DATE
	INSP.		DATE		NO DEFECTS		DEPT.		MECH.		DATE
____ CC	____ GAL.	INSIDE		OUTSIDE		LBS.			LD. MAN		DATE
									INSP.		DATE
	INSP.		DATE		NO DEFECTS		DEPT.		MECH.		DATE
____ CC	____ GAL.	INSIDE		OUTSIDE		LBS.			LD. MAN	R-3729P	DATE
A-48											
									INSP.		DATE

12. THRUST CHAMBER ALIGNMENT (FORM 612-H SERIES)*

12.1 Thrust Chamber Alignment Forms (612-H Series) are a specialized type of Inspection Sign-Off Record and are used to record the data obtained during the tests and measurements of the Rocket Engine Thrust Chamber alignment operation according to applicable Process Specifications.

12.1.1 The thrust alignment test and measurement operation is accomplished according to the Inspection Sign-Off Book callouts and applicable Rocketdyne Process Specifications by Manufacturing. The required data is recorded by Manufacturing and verified by the Inspector on the Thrust Alignment Forms.

12.1.2 The specialized forms are initiated, maintained and inserted in the ISO Books by the Process Control Group of Planning. The Inspector shall report any discrepancy between the ISO Record Sheets, the Process Specifications and the Thrust Alignment Record Forms as an Inspection Discrepancy and Correction Record (Form R 25-U) in the ISO Book and to the Inspection Leadman for reconciliation and Correction by Planning.

12.2 The Inspector shall verify all installation and alignment operations to the applicable specification.

12.3 The Inspector shall verify the required measurement taken by Manufacturing in the appropriate spaces provided on the Thrust Alignment Forms.

12.3.1 Adjustments or alignments disturbed after inspection "Buy-Off" by subsequent rework or adjustment operations shall be recorded by the Inspector as a discrepancy on Form R 25-U in the ISO Book.

12.3.2 Parts to be removed by Manufacturing shall be recorded (prior to their removal) on the Parts Removal Record and the operation verified by the Inspector.

12.4 The Thrust Alignment Record Forms are a permanent historical record of the assembly and are left in the Inspection Sign-Off Book when they are turned into Engine Clearance for processing and storage. At Neosho these forms are forwarded to Quality Control Analysis for the necessary duplication and insertion into the Engine Log Book.

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*See illustration on page 48.

ROCKETDYNE
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FIGURE I

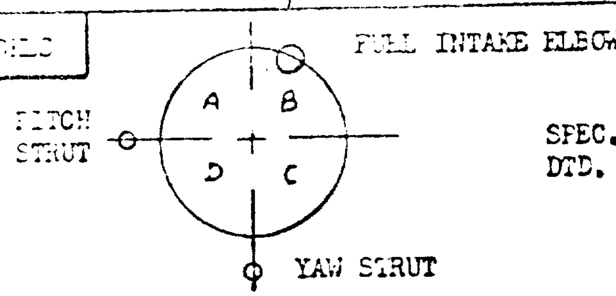
THRUST VECTOR ANGULAR ALIGNMENT DETERMINATION

ASSEMBLY ______________ S/N ______________

PART NO. OF THRUST CHAMBER ______________
S/N ______________ UNIT ________

DISTANCE BETWEEN INSIDE SURFACES OF DISKS AT ENDS OF TURNBUCKLES

READING NO.	PITCH STRUT		YAW STRUT	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
SUM				INCHES
AVERAGE		INCHES		INCHES
AL	15.153	INCHES	15.153	INCHES
* AVERAGE STRUT LENGTH		INCHES		INCHES
OVERALL LENGTH		INCHES		



SPEC. ______________
DTD. ______________

VIEW OF QUADRANTS AND STRUTS FROM TOP OF FIXTURE

* Readings were taken by rotating the "Spider" within the Thrust Chamber in approximately 18^{o} increments and adjusting the strut lengths to line up reflected crosshairs with eyepiece crosshairs; ie, to make "Spider" centerline parallel to optical centerline.

* Each average strut length is the distance from the center of the pin in the outrigger arm to the plane of the Gimbal Bearing to make the average geometrical centerline of the chamber assembly perpendicular to the plane of the Gimbal Bearing. Inspection Verification.

13. SAFETY INSPECTION VERIFICATION SHEET*

13.1 The Safety Inspection Verification Sheet is used by inspection to tabulate the discrepancies found during the Safety Inspection Check. This is accomplished after Hot-Fire and prior to the submittal of the engine to Customer Inspection. It forms a part of the permanent inspection records.

13.2 The Safety Inspection Verification Sheet is initiated and inserted as required in the ISO Book by the Process Control Group of Planning.

13.3 The Inspector shall be responsible for the accomplishment and the accuracy of all entries on the sheet.

13.3.1 The Assembly Part Number and Customer Serial Number shall be entered as shown on the Cover of the ISO Book.

13.3.2 The number of squawks for each entry shall be tabulated by the Inspector from the Form R 25-U written during the Safety Inspection (after Hot-Fire and prior to presentation to the customer for acceptance). Each total shall be entered, dated and acceptance stamped by the Inspector.

13.4 The Safety Inspection Verification Sheet is left in the ISO Book and is sent with it at "closeout" to Engine Clearance Inspection Records and Data Group.

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*See illustration on page 50.

SAFETY INSPECTION VERIFICATION SHEET

FOR SAFETY INSPECTION CHECK TO BE ACCOMPLISHED JUST PRIOR TO RELEASE OF ENGINE TO CUSTOMER INSPECTION

ENGINE MODEL ____________

ASSEMBLY PART NO. ____________

CUSTOMER ENGINE SERIAL NO. ____________

	VERIFICATIONS MADE BY THE INSPECTOR	DATE	No. of Squawks	STAMP
1.	Safety wire installed per B/P & Spec.			
2.	Electrical Clamps installed & Wire clearance found per B/P & Spec.			
3.	Electrical Plugs and Connectors tight.			
4.	Tubing & Lines identified per B/P & Spec.			
5.	Bolts re-torqued per ISO Book, B/P & Spec. & torque marked.			
6.	"B" Nuts, Jam Nuts & "O" Rings installed.			
7.	Fittings re-torqued & torque marked as noted in ISO Book, B/P & Spec.			
8.	Inspect Fuel & Oxide Inlet Flanges of the Turbo Pump for scratches or damage.			
	Customer Verification			

A-52 R-3729P

Safety Inspection Verification Sheet to be retained in ISO Book #

14. MCR VERIFICATION LIST*

14.1 The Master Change Record (MCR) Verification List is used as the permanent inspection source record of the accomplishment of required Engineering changes in configuration, process, or tests, made on the Rocket Engine or its components.

14.2 The MCR Verification Lists are initiated on a current basis by the Engine Clearance Group when notified by appropriate Contract Change Notice (CCN), Intermediate Stage Letter (ISL), Engineering Change Proposal (ECP) and Master Change Record (MCR).

14.2.1 The MCR List Heading notes the date, contract, the affected Engine Model type and model numbers, the G.O. number and the latest revision date.

14.2.2 The body of the list outlines the details of the changes required with the appropriate MCR No., Reference number, effectivity (by serial number) the detail description of the changes required as well as the location where the "BUY-OFF" of the change is to occur. Space is provided for the Inspector (that verifies the change or its acceptance) to date and stamp his responsibility.

14.3 Current MCR Lists are issued as required by the Engine Clearance Group to the Inspection Leadmen for insertion into each affected Inspection Sign-Off (ISO) Book.

14.4 The Inspector shall verify and acceptance stamp each MCR listed and accomplished.

14.4.1 The CVR Book List of cleared changes may be utilized by the Inspector for the verification of the accomplishment of changes required on the MCR List.

14.5 When a currently revised MCR Verification List is initiated, the Inspector shall remove the superseded list and reverify the accomplishment of each MCR listed.

14.6 At completion of the ISO Book the MCR Verification List shall be audited by the Inspection Leadman and left in the ISO Book as part of the historical inspection records.

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*See illustration on page 52.

FORM R 154-H-2

M.C.R. - MD NUMBER VERIFICATION LIST

PAGE of

FROM: ENGINE CLEARANCE
PHONE:
ENGINE MODEL:

DATE:
CONTRACT:
REV. DATE:

M.C.R. NUMBER	MD NO.	EFFECTIVE ON	E.O. NO'S RELEASING CHANGE	TITLE	DEPT. RESPON.	DEPT. MECH.	DEPT. INSP.

15. STRUCTURAL APPROVAL AND MATERIALS REVIEW FORM #60-W - ACTION IN THE INSPECTION SIGN-OFF BOOK*

15.1 This form as a Materials Review and Inspection Supervision Disposition (ISD) Form, is used in the ISO Book to record the discrepancies noted by inspection which cannot be accepted to the required drawings or specifications. This form also provides a uniform manner of recording the disposition.

15.2 Initiation: When an Inspection Discrepancy and Correction Records (Form R 25-U) entry requires a disposition approved by inspection supervision or Materials Review, the complete report is copies by the inspector on to the Structural Approval and Materials Review (Form 60-W) in the same Inspection Sign-Off Bo[illegible]

15.2.1 60-W action shall be initiated only when authorized by inspection supervision.

15.2.2 All inspection entries shall be legibly written or printed in ink. All entries made by Materials Review engineers shall be legibly written or printed in ink.

15.2.3 Erasures shall not be made. Inspection correction to original entries shall be made by striking out the error with a single line and stamping the entry. Corrections shall be made only by the person who made the entry or by Inspection Supervision.

15.2.3.1 Changes to disposition entries made by a Materials Review Engineer shall be made and signed by a Materials Review Engineer.

15.2.4 The Form R 25-U entry shall be left open until the disposition has been approved and any rework required has been accomplished and accepted.

15.2.5 All 60-W Forms are to remain in the Inspection Sign-Off Books as permanent records of Inspection and Materials Review action.

15.3 THE ACCOMPLISHMENT OF THE FORM 60-W SHALL BE AS FOLLOWS:

15.3.1 UNIT, SERIAL OR SHIP (R/E) NUMBER: Circle correct description and enter the numbers from the Inspection Sign-Off (ISO) Book cover.

15.3.2 ASSEMBLY NUMBER: Enter number as shown on cover of ISO Book. .

15.3.3 All 60-W actions shall be numbered consecutively by the initiator in the left-hand margin with the discrepancy starting at #1 in each ISO Book. This number shall be cross referenced on the Form R 25-U.

*See illustration on page 57.

15.3.4 "INSP. AUTH." BLOCK: The round acceptance stamp of the authorizing Inspection Leadman or the Inspection Supervisor's triangle acceptance stamp is placed here. Dispositions approved by a Materials Review engineer shall be triangle acceptance stamped in this block by an inspection supervisor, indicating concurrence with the Materials Review engineer's disposition.

15.3.5 "MAT. REV. ENG." DATE: If Materials Review approval is required, the Materials Review Engineer will sign in this block.

15.3.5.1 The date the disposition is authorized shall also be entered.

15.3.6 PART NUMBER: Enter the number of the detail part that is discrepant.

15.3.7 TYPE OF REPAIR: Inspection is to enter, "Standard Repair No._____," "ISD". The MR engineer will enter MRD or 23-H-1 number whichever is applicable.

15.3.8 DISCREPANCY: Copy the discrepancy entry in detail and reference the number of the discrepancy entry in the left-hand margin as "REF. DCP #____" (below the 60-W ACTION NUMBER).

15.3.9 DISPOSITION: This is the detailed dispostion for acceptance, replacement, or repair of the discrepant item and is filled in by the Materials Review engineer for MRD's and by Inspection leadmen or supervision for Standard Repairs and ISD's.

15.3.9.1 Special tests or inspections required for acceptance shall be listed here in detail and verified by Inspection as completed.

15.3.9.2 HOLE CHECK: Inspector will place his acceptance stamp impression here after accepting holes which were drilled in order to accomplish repair.

15.3.9.3 MATERIAL CHECK: Inspector will place his acceptance stamp impression here after accepting materials which were used to accomplish repair.

15.3.10 The Mechanic's clock number making the repair and date completed should be entered by the mechanic.

15.3.11 INSP. ACCEPT.: The triangle acceptance stamp of an inspection supervisor will be applied here indicating satisfactory completion of rework or concurrence with "USE AS IS" dispostion.

15.3.12 CUST.: The inspector shall have the customer place his acceptance stamp here when required.

15.4 TRANSFERRING OF INCOMPLETE 60-W ITEMS

15.4.1 Incomplete repairs (Std. Repairs, ISD's, or MRD's) which have not been worked in the originating department or section, must be transferred as follows when the original Sign-Off Book is otherwise ready to be closed out and separated from the assembly:

15.4.1.1 The incomplete item will be copied complete on a new Form 60-W. The wording must be exactly the same as on the original. The sequence number must be noted in the left-hand margin.

When the material and/or hole check has been stamped on the original, the inspector will stamp the duplicate and note "TFO" (Transferred from Original) adjacent to his stamp.

15.4.1.2 The new item will be noted in the left-hand margin, "Transferred from Original Book number ________," and 60-W #________."

15.4.2 The new Form 60-W (with a new shortage report) will accompany the assembly (installation of these forms in the new Sign-Off Book shall be checked by the Inspection Leadman at close-out of the original ISO Book).

15.4.3 Inspection in the originating department will be responsible for obtaining necessary authorization stamps and/or signature on the new 60-W form.

15.4.4 The original item will be noted, "Transferred to Next Department" and the inspector will stamp adjacent to this notation, verifying the transfer to new sheet. The original must remain in the Sign-Off Book.

15.5 When a Structural Approval and Materials Review Form 60-W is submitted for Inspection Supervision or Materials Review Disposition, a Quality History Card (Form 609-R) will be initiated and accompany the 60-W Form.

15.5.1 The Quality History Card will be completed in accordance with Quality Control Operating Procedure R-4.4.

15.5.2 Completed Quality History Cards shall be reviewed by the person authorizing disposition (Materials Review engineer or Inspection Supervision) to determine the requirements of corrective action.

15.5.3 When required, the customer's representative will indicate concurrence by placing his acceptance stamp adjacent to the 609-R Card's serial number.

15.5.4 Upon completion of the above action, the 609-R cards will be forwarded to Quality Assurance.

15.6 REWORK ACCOMPLISHED BY OTHER DEPARTMENTS

15.6.1 Rework accomplished by other production departments may be authorized on planning tickets or PRR's. In either case, inspection operations should be transferred to the 60-W Form referencing the other Form's serial number.

STRUCTURAL APPROVAL & MATERIALS REVIEW

UNIT, SERIAL OR SHIP NO. (CIRCLE ONE) ______________ ASSEMBLY NO. ______________

INSP. AUTH.	MAT. REV. ENG.	PART NO.	TYPE OF REPAIR	MECH. NO.	INSP. ACCEPT.	CUST.
	DATE			DATE		

Discrepancy	Disposition		
		HOLE CK.	
		MAT. CK.	

INSP. AUTH.	MAT. REV. ENG.	PART NO.	TYPE OF REPAIR	MECH. NO.	INSP. ACCEPT.	CUST.
	DATE			DATE		

Discrepancy	Disposition		
		HOLE CK.	
		MAT. CK.	

INSP. AUTH.	MAT. REV. ENG.	PART NO.	TYPE OF REPAIR	MECH. NO.	INSP. ACCEPT.	CUST.
	DATE			DATE		

Discrepancy	Disposition		
		HOLE CK.	
		MAT. CK.	

APPENDIX B

MODEL SPECIFICATION OUTLINE

OUTLINE OF ROCKETDYNE ENGINE
MODEL SPECIFICATION
(SAMPLE)

Paragraph

Paragraph

Paragraph

(6626)	4.2	Rocket engine inspections and tests
(6626)	4.2.1	Rocket engine tests
(6626)	4.2.2	Rocket engine inspection after test
(6626)	4.3	Component inspection and tests
(6626)	5.	PREPARATION FOR DELIVERY
(6626)	6.	NOTES
(6626)	6.1	Intended use
(6626)	6.2	Definitions and symbols
	4.2.4	Acceptance tests
(5152)	1.	SCOPE
(5152)	2.	APPLICABLE DOCUMENTS
(5152)	3.	REQUIREMENTS
(5152)	3.1	Contractor's instructions, specifications and drawings
(5152)	3.1.1	Specifications
(5152)	3.1.2	Component calibration
(5152)	3.1.3	Availability
(5152)	3.2	Acceptance-test data
(5152)	3.2.1	General
(5152)	3.2.2	Log
(5152)	4.	QUALITY ASSURANCE PROVISIONS
(5152)	4.1	General
(5152)	4.1.1	Test apparatus and procedures
(5152)	4.1.3	Test temperatures
(5152)	4.2	Acceptance tests

APPENDIX C

ROCKET ENGINE LOG BOOK

TITLE: PREPARATION AND USE OF THE ROCKET ENGINE LOG BOOK

APPLICATION

The Rocket Engine Log Book is prepared by the Engine Clearance Group for the purpose of disseminating pertinent information relative to engine configuration and performance for submittal to the customer. This procedure will act as a guide for inspection personnel in the use of engine log books applicable to rocket engines manufactured, tested and shipped by Rocketdyne Canoga, Van Nuys and Neosho.

1. The Rocket Engine Log Book shall be divided into four sections. The first page beneath the Log Book cover will be the "ENGINE IDENTIFICATION." (See Figure I)

   The second page will be the "FOREWORD" page. (See Figure II)

   The third page will be the "ABBREVIATION LIST OF ROCKETDYNE TERMS"

SECTION I

1.1 Engine Time Log Section Divider.

1.1.1 Engine Time Log Form (See Figure IV for sample).

SECTION II

1.2 Acceptance Test Log Section Divider.

1.2.1 Engine Data Log Form (See Figure V for sample).

1.2.2 Thrust Vector Angular Alignment Determination Form (See Figure VI for sample).

1.2.3 Moment of Inertia Form (See Figure VII for sample).

1.2.4 Engine Weighing Form (See Figure VIII and VIIIa for sample).

1.2.5 Acceptance Test Log Instruction Sheet (See Figure IX for sample).

1.2.6 Acceptance Test Log Form (See Figure X for sample).

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* Supersedes R-1.29 dated 9 September 1957. General Revision.

SECTION III

1.3 Orifice Sizes Section Divider

1.3.1 Orifice Size Form (See Figure XI for sample).

SECTION IV

1.4 Engine Historical Records Section Divider

1.4.1 Component Replacement Record Form AFTO-2B

1.4.2 Outstanding/Delayed Maintenance Record Form AFTO-2D

1.4.3 Component Historical Record Form AFTO-2E

1.4.4 Forms DD829 and DD829-2 shall be used in lieu of above forms, paragraphs 1.4.1 through 1.4.4 for R & D engines.

2. GENERAL INSTRUCTIONS

The following rules pertain to the accumulation, compiling and transmittal of data and the assembly of the log book.

2.1 Certain portions of the acceptance log shall be reproducible. All other entries shall be non-reproducible. See the specific Engineering Process Specification for detail instructions.

2.1.1 All entries made in the Rocket Engine Log Book shall be written in ink and/or typed in black for permanent record.

2.1.2 Erasures in the Rocket Engine Log Book are strictly prohibited. Errors shall be corrected by retyping the page involved.

2.1.3 Entries such as rework, kit installations, removals, missile mating, additional static testing time, and custody shall be made by the customer or Rocketdyne Field Service personnel.

2.1.4 If for any reason an engine is returned for modification and/or repairs, the Rocket Engine Log Book must accompany the engine. Engine modification and/or repair entries shall be made by Rocketdyne personnel.

2.1.5 The abbreviations "UNK" and "DNA" shall be inserted in blank spaces for which information is Unknown or Does Not Apply. Do not leave the space blank.

3. ASSEMBLING THE ROCKET ENGINE LOG BOOK

3.1 Engine Log Book Identification Form
The Engine Log Book Identification Form (See Figure I for sample).

3.2 Identifies the engine concerned by model number and serial number.

3.3 Outlines the format of the Rocket Engine Log Book.

4. THE FOLLOWING PROCEDURE SPECIFIES HOW THE ENGINE LOG BOOK IDENTIFICATION FORM SHALL BE COMPLETED. SEE APPLICABLE PROCESS SPECIFICATIONS FOR SPECIFIC INFORMATION.

4.1 Manufacture of Engine: Enter "ROCKETDYNE, A DIVISION OF NORTH AMERICAN AVIATION"

4.2 Model: Enter the customer's designated model identification number in the space provided at the upper left hand corner of the form.

4.3 Serial No.: Enter the applicable engine serial number in the appropriate spaces at the upper left hand corner and lower right hand corner of the form.

4.4 Model No.: Enter Rocketdyne's model configuration number in the appropriate space at the lower right hand corner of the form.

4.5 Contract Number: Enter the complete customer assigned contract number in the space provided at the upper left hand corner of the form.

4.6 Foreword: Foreword form (See Figure II for sample) shall be included in the Rocket Engine Log Book.

4.7 Abbreviation List: The Rocket Engine Log Book shall contain an abbreviation list of Rocketdyne terms (See Figure III for sample).

4.8 Section I

Engine Time Log: Engine time log form (See Figure IV for sample) shall be included in the log book for the customer's use. Enter the complete customer's designated model identification number and serial number in the spaces provided at the top of the form. No other entries shall be made on this page at Rocketdyne.

4.8.1 A time log form shall be provided for individual engines within a propulsion system, i.e., booster, sustainer or vernier.

4.9 Section II

Acceptance Test Log: (See Figure X for sample) This log shall contain the record of the Engine Post Acceptance electro-mechanical check out and conditioning by specification number, revision date, location, and organization.

Type in the space beneath the word "Supplier" the acceptance stamp number of the responsible Rocketdyne Quality Control representative monitoring the engine processing using type-writer carbon orange backing for reproduction purposes. In the space beneath the word "Government" - enter name of government inspector or responsible representative monitoring each engine process.

4.10 Section III

Orifice Sizes: The orifice size form (See Figure XI for sample) shall be included in the Rocket Engine Log Book for the customer use. No other entries will be made by Rocketdyne on this page.

4.11 Section IV

Engine Historical Records: The following forms make the complete engine historical record section of the Log Book.

4.11.1 Component Replacement Record: The component replacement record form is AFTO Form 2B and shall be filled in according to the requirements of MIL-R-7634, Exhibit 57-16 and T.O. 00-20E-1.

4.11.2 Outstanding/Delayed Maintenance Record: The outstanding/delayed maintenance record form is AFTO Form 2D and shall be filled in according to the requirements of MIL-R-7634, Exhibit 57-16 and T.O. 00-20E-1.

4.11.3 Component Historical Record: The component historical record is AFTO Form 2E and shall be filled in according to the requirements of MIL-R-7634, Exhibit 57-16 and T.O. 00-20E-1.

4.11.4 The DD829 Historical Record for Aeronautical Equipment, and DD829-2 Historical Record Data, shall be completed in accordance with the requirements of MIL-R-7634 and T.O. 00-20A-1.

4.11.4.1 As specific military requirements have not been released for the administration of technical and historical records for ORD and NASA rocket engines, the requirements stipulated in MIL-R-7634 and T.O. 00-20A-1 will govern the preparation of DD829 forms for these units.

4.11.5 Records for rocket engines delivered to the Department of Navy shall be completed in accordance with instructions contained in government furnished log books and applicable contract.

5. DETAIL INSTRUCTIONS FOR INDIVIDUAL CONTRACTS

Detail instructions and information to be entered in the accompanying Rocket Engine Log Book is covered in one of the following Rocketdyne Engineering Process Specifications.

5.1 Atlas Sustainer (XLR 105-NA-5) (See Process Specification RA 0298-001.)

5.1.1 Atlas Booster (XLR-89-NA-5) (See Process Specification RA 0298-003.)

5.1.2 Saturn Booster (H-1) (See Process Specification RA 0298-002.)

ENGINE LOG BOOK

ENGINE IDENTIFICATION

MANUFACTURER OF ENGINE ______________________________

MODEL ______________________________

SERIAL NUMBER ______________________________

CONTRACT NUMBER ______________________________

GENERAL INFORMATION

This Log Book is provided for service use in recording all changes from the original configuration and pertinent historical data. It shall accompany the Engine when transferred between facilities and using agencies. When the Engine is installed in a vehicle, this shall be kept in the vehicle records.

SECTION I - ENGINE TIME LOG

Time Log Section is provided for accumulation of time between transfers of the Engine. Enter here. Record of Run Numbers, Purpose of Run, Firing Time (for the purpose of accumulating total Engine time). Include in remarks column: Any data pertinent to failure of component, rough combustion or any other abnormal conditions.

SECTION II - ACCEPTANCE TEST LOG

This is a record of the Engine Acceptance Test.

SECTION III - ORIFICE SIZES

The Orifice Sizes of Variable Orifices will be entered here when any changes are made in Orifice Sizes. Note: Record any replacement of Orifices whether or not the sizes change.

SECTION IV - ENGINE HISTORICAL RECORDS

The Historical Information will be entered on AFTO and/or DD829 form series as required.

Serial No. Model No.

FIGURE I

FOREWORD

LIQUID PROPELLANT ROCKET ENGINE

THIS BOOK CONTAINS INFORMATION PERTINENT TO THE ROCKET ENGINE AS SPECIFIED HEREIN BY SERIAL NO. AND MODEL NO. IT IS NECESSARY THAT ALL ENTRIES BE WRITTEN IN INK OR TYPED FOR PERMANENT RECORD. ENTRIES SUCH AS CUSTODY, PRESERVATION, SERIALIZATION, APPLICABLE E.C.P.'S, ACCEPTANCE RUN DATA, CALIBRATION, ALIGNMENT SHEETS AND WEIGHT DATA WHERE APPLICABLE WILL BE ENTERED BY ROCKETDYNE AT TIME OF DELIVERY. ENTRIES SUCH AS REWORK, KIT INSTALLATION, REMOVALS, MISSILE MATING, ADDITIONAL STATIC FIRING TIME AND CUSTODY WILL BE MADE BY THE CUSTOMER.

IF FOR ANY REASON THIS ENGINE IS RETURNED TO ROCKETDYNE FOR MODIFICATION AND/OR REPAIRS, THIS LOG BOOK MUST ACCOMPANY THE ENGINE. MODIFICATION ENTRIES WILL BE ENTERED BY ROCKETDYNE AND CUSTODY RECORD WILL BE MAINTAINED.

ERASURES ARE PROHIBITED.

FIGURE II

ABBREVIATION LIST OF ROCKETDYNE TERMS (Ref: RA 0299-002)

Access G/B	Accessory Gear Box
A/F	Air Force
Assy	Assembly
Brkt	Bracket
BRL	Booster Reference Line
C/P	Canoga Park
CP	Control Pressure
Cal	Calibration
Cap	Capability
Diaph	Diaphragm
DNA	Does Not Apply
DUR	Duration
Elect	Electrical
Eng. Mt.	Engine Mount
Ex Duct	Exhaust Duct
F	Fahrenheit
GG	Gas Generator
Gr Box	Ground Box
Gim	Gimbal
GN_2	Gaseous Nitrogen
HE	Heat Exchanger
HP	High Pressure
In	Inches
Inj	Injector
Inlet	Pressure Inlet Part of Solenoid Valve
IFV	Igniter Fuel Valve
JP	Fuel Developed by Jet Prop. Lab
KIPS	Thousands
LOX	Liquid Oxygen
LOX Reg	LOX Regulator Valve Assy.
LST	LOX Start Tank
LUB	Lube or Lubricant
LB	Pound
MFV	Main Fuel Valve
MLV	Main LOX Valve
MLVV	Main LOX Vent Valve
MS	Main Stage
MSim	Missile Simulator
ms	Milliseconds
GN_2	Nitrogen Gas
NC	Normally Closed (un-energized)
NO	Normally Open (un-energized)
Norm	Normally
O/C	O'clock
OP/C	Opening Control
Pnu	Pneumatic
PSTC	Pneumatic System Test Console
Pre	Preliminary
Perf	Performance
P/N	Part Number
PSIA	Pounds per Square Inch Absolute
PSIG	Pounds per Square Inch Gage
Reg.	Regulator
RE	Rocket Engine
RERB	Rocket Engine Relay Box
RPP	Rocket Power Panel
Recal	Recalibration
Rept	Repeatability
S/B	Should Be
S/N	Serial Number
Sq	Squawk
Sta	Station
Sol	Solenoid Valve
Sec	Second
SPGG	Solid Propellant Gas Generator
T/C	Thrust Chamber
T/P	Turbo Pump
Tur	Turbine
UDMH-DETA or HYDYNE	Unsymmetrical Di-Methyl Hydrazine Di-Ethyle Triamine Hydne
UNK	Unknown

FIGURE III

ENGINE TIME LOG

MODEL ____________ SERIAL NO. ____________

DATE	TEST STAND MISSILE BOOSTER NO.	RUN NO.	RUN TYPE OR PURPOSE	FIRING TIME - SEC IGNITION STAGE	FIRING TIME - SEC MAINSTAGE	REMARKS

FIGURE IV

SUSTAINER ENGINE DATA LOG

Page 1

MODEL NUMBER	CONTRACT NUMBER	ENGINE SERIAL NO.

FINAL ACCEPTANCE DATE	TOTAL ENGINE TIME	TOTAL ENGINE STARTS	ENGINE DRY WEIGHT

	COMPONENT	PART NUMBER	SERIAL NUMBER	NO. OF STARTS	TEST TIME
1	THRUST CHAMBER				SEC
2	INJECTOR				SEC
3	TURBOPUMP				SEC

DELIVERED ORIFICE SIZES			VERNIER BLEED PRESSURES		
4	GAS GENERATOR FUEL		7	VERNIER OXIDIZER BLEED PRESSURE	PSIA
5	VERNIER ENGINE OXIDIZER BLEED		8	VERNIER FUEL BLEED PRESSURE	PSIA
6	VERNIER ENGINE FUEL BLEED				

REGULAR SETTING			PREDICTED ENGINE PERFORMANCE		
9	OXIDIZER REGULATOR SETTING		12	THRUST	KIPS
10	MIXTURE RATIO CONTROLLER FUEL SENSE PRESSURE		13	MIXTURE RATIO	O/F
11	MIXTURE RATIO CONTROLLER DIFFERENTIAL SENSE PRESSURE		14	SPECIFIC IMPULSE	SEC

OPTICAL ALIGNMENT DATA				
15	X ALIGNMENT AVG ARM LENGTH	IN	Z ALIGNMENT AVG ARM LENGTH	IN

APPROVAL SIGNATURES					
ROCKETDYNE ENGINEERING	DATE	ROCKETDYNE INSPECTION	DATE	CUSTOMER	DATE

FIGURE V

FIGURE I.

THRUST VECTOR ANGULAR ALIGNMENT DETERMINATION

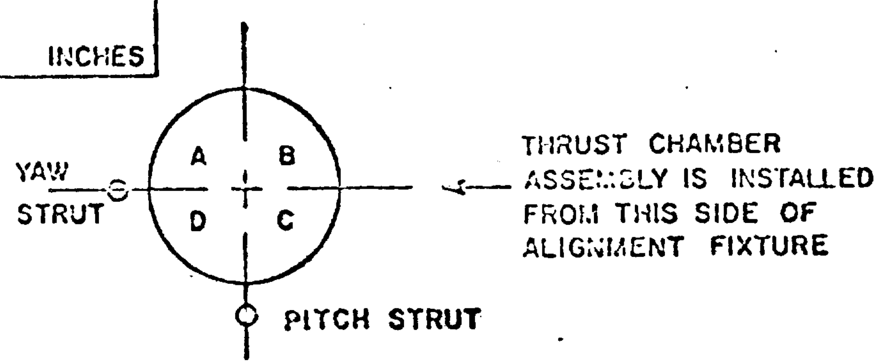
THRUST CHAMBER PART NO.__________ S/N______

S-4 ENGINE__________ S/N__________

ASSEMBLY______________________

S/N ______________________

** READING NO.	DISTANCE BETWEEN INSIDE SURFACES OF DISKS AT ENDS OF TURNBUCKLES	
	PITCH STRUT	YAW STRUT
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
SUM		
AVERAGE	INCHES	INCHES
ADD →	4.504 INCHES	4.504 INCHES
*AVERAGE STRUT LENGTH	INCHES	INCHES
OVERALL LENGTH	INCHES	



SPEC. __________

DTD. __________

INSPECTOR______________ STAMP____________ DATE ________________

VIEW OF QUADRANTS AND STRUTS FROM TOP OF FIXTURE

** READINGS WERE TAKEN BY ROTATING THE "SPIDER" WITHIN THE THRUST CHAMBER IN APPROXIMATELY 18° INCREMENTS AND ADJUSTING THE STRUT LENGTHS TO LINE UP REFLECTED CROSSHAIRS WITH EYEPIECE CROSSHAIRS; I.E., TO MAKE "SPIDER" CENTERLINE PARALLEL TO OPTICAL CENTERLINE.

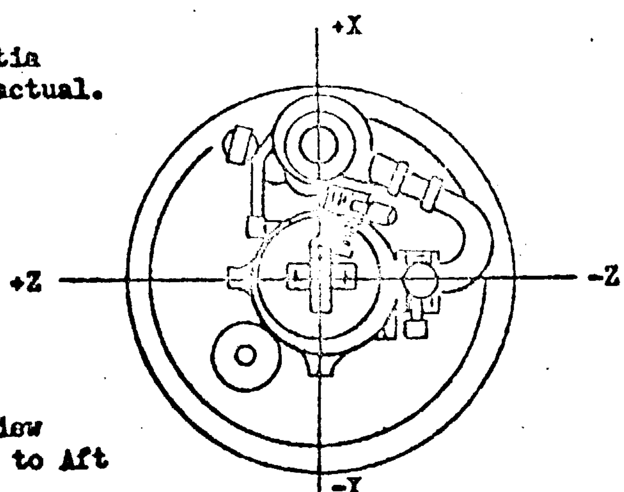
* EACH AVERAGE STRUT LENGTH IN THE DISTANCE FROM THE CENTER OF THE PIN IN THE OUTRIGGER ARM TO THE PLANE OF THE GIMBAL BEARING TO MAKE THE AVERAGE GEOMETRICAL CENTERLINE OF THE CHAMBER ASSEMBLY PERPENDICULAR TO THE PLANE OF THE GIMBAL BEARING

(ESTIMATED) (CALCULATED) (ACTUAL) DETERMINATION OF MOMENT OF INERTIA & CENTER OF GRAVITY FOR GIMBAL [illegible]

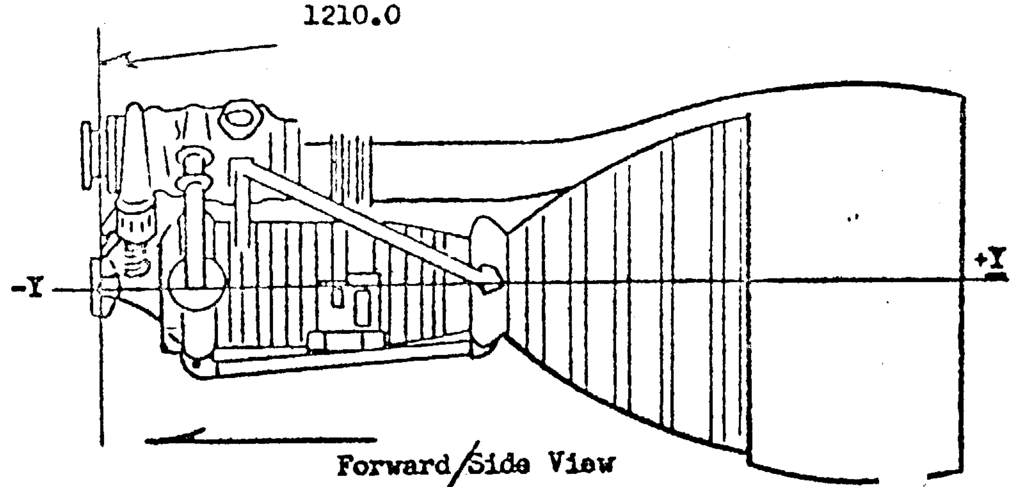
Prepared By:				Date:			
Manufacturers Model	Model		Serial No.			Engine No.	
Body Assembly P/N			Body Assembly Serial No.				
	Weight	Y Arm	X Arm	Z Arm	Iyy - Roll	Ixx - Yaw	Izz - Pitch
DRY CONDITION	Pounds	Inches	Inches	Inches	Slug Ft.^{2}	Slug Ft.^{2}	Slug Ft.^{2}
Engine Assembly as Tested							
*Basic Items Added							
*Non-Basic Items Removed							
*Non-Gimbal Items Removed							
Total Gimbal Mass About Gimbal Axis	( )				( )	( )	( )
WET CONDITION							
Engine Assembly Dry							
*Fluid in Thrust Chamber							
*Additional Fluid							
Total Gimbal Mass About Gimbal Axis	( )				( )	( )	( )

NOTE: *Data determined by calculations.

Total Inertia
is ____% actual.



View
...rd. to Aft



Forward/Side View

FIGURE VII

ENGINE WEIGHING FORM

DATE WEIGHED ________________ MODEL ________________ SERIAL NO. ________

PLACE WEIGHED ________________ WEIGHED BY ____________ INSPECTOR ________

CELL LOCATION	CELL	SCALE READING	TARE	CELL ERROR	NET WEIGHT	ARM	MOMENT
FWD LEFT							
FWD RIGHT							
FWD CENTER							
Sub total fwd							
AFT LEFT							
AFT RIGHT							
AFT CENTER							
Subtotal aft							
TOTAL as weighed							

MEASUREMENTS & COMPUTATION OF CENTER OF GRAVITY

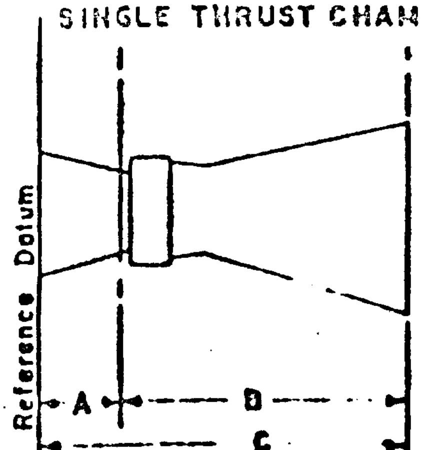
A ________ Inches, the distance from reference datum to forward jig point.

C ________ Inches, the distance from reference datum to aft jig point.

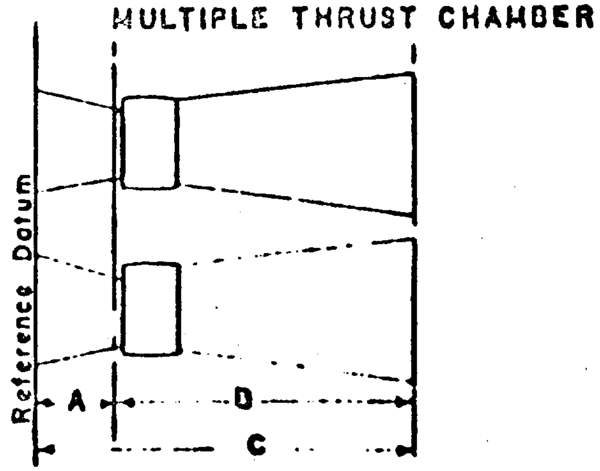
B ________ Inches, the distance to aft jig point less distance to fwd jig point.

$$C.G. = A + \frac{(AFT\ WEIGHT) \times (B)}{TOTAL\ WEIGHT} = \quad \text{Inches}$$

SINGLE THRUST CHAMBER



MULTIPLE THRUST CHAMBER



Diagrams for measuring various types of engines to determine arms of support points.

WEIGHING RECORD

DESCRIPTION	NET WEIGHT	ARM	MOMENT
TOTAL (As Weighed)			
TOTAL OF ITEMS WEIGHED BUT NOT PART OF BASIC WEIGHT (col. I below)			
TOTAL OF BASIC ITEMS NOT IN ENGINE WHEN WEIGHED (col. II below)			
BASIC ENGINE WEIGHT			

COLUMN I				COLUMN II			
ITEMS WEIGHED NOT PT of BAS WT	WEIGHT	ARM	MOMENT	BASIC ITEMS NOT ON WEIGHED ENG	WEIGHT	ARM	MOMENT
TOTAL				TOTAL			

REMARKS:

WITNESSED BY:

FIGURE VIII A

INSTRUCTIONS FOR

ACCEPTANCE TEST LOG

1. This log shall be used to record all pertinent acceptance data.

2. Enter the location at which the test was performed and the division, branch, or laboratory of the contractor or the Government that is performing the test.

3. In order to enable using personnel and the inspectors to make a determination as to the acceptability and provide uniform test requirements, the acceptance test specification number, revision and title if of vital importance.

4. All columns shall contain pertinent information.

FIGURE IX

ACCEPTANCE TEST LOG

MODEL ________ ENGINE S/N ________

DATE	TEST LOCATION AND ORGANIZATION	SPECIFICATION NO.&REVISION	SPECIFICATION TITLE	INSPECTORS' SIGNATURE	
				SUPPLIER	GOVERNMENT

REMARKS ________

FIGURE X

ORIFICE SIZES

MODEL ____________________ S/N ____________________

LOCATION	PART NO.	REPLACEMENT			
		SIZE	INSP.	SIZE	INSP.

FIGURE XI

APPENDIX D

PROCESS SPECIFICATION

1. SCOPE AND LIMITATIONS:

1.1 Scope: This specification covers the preparation and operation of preliminary "strike" solutions and copper plating bath for plating of materials detailed below:

1.2 Limitations: Three procedures for copper plating are described herein. Usage of each shall be as follows:

1.2.1 Procedures detailed in Table I shall be for all ferrous alloys (stainless excluded) and all copper and copper alloys.

1.2.2 Procedures detailed in Table II shall be used on the AISI 400 series corrosion resistant steels including, but not limited to;

QQ-S-763	Class 410	AISI 410
" " "	" 416	" 416
" " "	" 431	" 431
AMS 5628		" 431
QQ-S-763	Class 440	" 440C

1.2.3 Procedures detailed in Table III shall be used on the 300 series stainless steels, Inconel, Inconel X and Inco 718.

1.2.4 Procedures detailed in Table IV shall be used for stripping copper plate (when required) from the above materials.

2. APPLICABLE MATERIALS AND SPECIFICATIONS:

2.1 Materials: Copper Cyanide (Technical Grade, 70-71 percent copper)
Potassium Cyanide (Technical Grade, 94-96 percent Granular)
Hydrochloric Acid (Technical Grade)
Nickel Chloride (Technical Grade)
Potassium Carbonate (Federal Specification O-P-552)
Chromic Acid (Federal Specification O-C-303)
Sulfuric Acid (Federal Specification O-S-801)
Potassium Hydroxide (Technical Grade)
Enthone "Enstrip S" or equivalent
DuPont "Coppralyte" Addition Agent 1085 or equivalent
Wyandotte F.S. Steel Cleaner or equivalent
"OFHC" (Oxygen-free high conductivity) copper anodes or equivalent

2.2 Specifications:

RB0210-101	Bright Dip, Copper and Copper Alloys
FR1-14	Vapor Degreasing
FR3-4	Prevention and Elimination of Hydrogen Embrittlement in Steel
FR7-2	Safety in Handling and Use of Chemicals
RB0210-002	Cleaner, Non-Foaming, Non-Silicated, Mild Alkaline
RB0210-005	Mild Alkaline Cleaner

3. GENERAL REQUIREMENTS:

3.1 Safety: Hazardous chemicals employed in this process shall be handled in accordance with NAA Specification FR7-2 and instructions from the Safety Department.

4. DETAIL REQUIREMENTS:

Procedures shall be per Table I, II or III, subject to the limitations established in paragraph 1.2.

5. QUALITY CONTROL:

5.1 Condition: Plated copper shall be smooth, adherent, uniform in appearance, free from pin holes, blisters, nodules, pits or other defects. Slight staining or discoloration will not be cause for rejection.

5.2 Plating Thickness: Except as specified below, plating thickness shall be as called out on the drawing:

5.2.1 Where "Copper Flash" is specified, thickness shall be approximately 0.0001 inch.

5.2.2 Copper plating applied for carburizing stop-off shall be at least 0.0002 inch thick.

NOTE: On parts with recessed areas, it may be necessary to plate up to 0.001 inch on some areas in order to throw the required thickness into the recesses.

5.3 Thickness Determination: Determination of plating thickness shall be made either on the parts, or on separate test specimens representive of the parts and plated simultaneously with them. One of the following methods shall be used.

5.3.1 Using accurate micrometer, determine thickness of a given location on a part or test specimen, before and after plating.

5.3.2 Use a magnetic gage method approved by Production Development Laboratory for checking plated parts.

5.4 Adhesion: Plated metal shall be firmly and continously bonded to the base metal as determined by either of the following methods:

5.4.1 Parts, or panels plated concurrently with the parts, shall be capable of withstanding a shear or chisel test, so conducted as to indicate quality of bond. Copper shall shear away, with no separation of plating and base metal.

5.4.2 Adhesion shall be determined by bend test either of parts, or panels plated concurrently with parts. The part or test panel shall be bent repeatedly through an angle of 180 degrees on a diameter equal to the base metal thickness. Following fracture of the base metal, it shall not be possible to detach any appreciable non-adherent area of the plating with a sharp instrument.

6. STRIPPING:

6.1 Stripping of copper when required, from ferrous alloys, copper, copper alloys, series 300 and 400 series stainless shall be accomplished by the procedure in Table IV.

TABLE I

PROCEDURE FOR COPPER PLATING FERROUS ALLOYS (STAINLESS INCLUDED) COPPER AND COPPER ALLOYS

4.1 OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION	TEMP, F	TIME	DETAILS
4.1.1 Clean					Remove grease, oil, etc. per PR1-14
4.1.2 Alkaline Clean	RB0210-002 preferred. (RB0210-005 may be used)	6 - 8 oz/gal	180-210	1 1/2-2 minutes	Make part anodic 4-6 volts. Parts shall rinse free of water break and have no visible residue on surfaces.
4.1.3 Water Rinse	Tap Water		Room	10 sec. min.	Water should be free flowing
4.1.4 Activate					
(a) Steel	Hydrochloric Acid	25 - 40% (by wt.)	Room	30-120 sec.	Subject to restrictions of PR3-4.
	or Sulfuric Acid	25 ± 2% (by wt.)	Room	5 minute max.	Make part anodic 200 ± 20 Amp/Sq.Ft. current density
(b) Copper Alloys	Hydrochloric Acid	25 - 40% (by wt.)	Room	30-120 sec.	
	(if necessary Bright Dip per LB0210-101)		Room	2-30 sec.	Use only if discolored or scaled
4.1.5 Rinse	Tap Water		Room	10 sec. min.	Water should be free flowing
4.1.6 Copper "Strike" Plate 3 1	(Bath Makeup) Potassium Cyanide Copper Cyanide Caustic Potash	Optimum oz/gal / Range oz/gal 6.5 / 4.9-7.8 3.5 / 2.8-4.2	120-140	As required 30-180 sec.	4-6 volts. Work is cathodic and should gas copiously.

TABLE I (CONTINUED)
PROCEDURE FOR COPPER PLATING FERROUS ALLOYS (STAINLESS EXCLUDED) COPPER AND COPPER ALLOYS

OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION		TEMP F.	TIME	DETAILS
4.1.7 Water Rinse (Optional)	Tap Water			room	10 sec. (minimum)	Running water at all times. Do not use same tanks as used after cleaning operation
4.1.8 Copper Plate ②	(Bath Makeup) Potassium Cyanide Copper Cyanide Caustic Potash DuPont Coppralyte Addition Agent 1085** Potassium Thiocyanate or equivalent	 13.7 oz/gal 8.3 oz/gal 5.6 oz/gal 6.0 cc/gal 2.25 oz/gal	 12.8-14.6 oz/gal 7.8-8.7 oz/gal 5.0-6.0 oz/gal 4.0-8.0 cc/gal 1.0-2.5 oz/gal	150-160	As required	Anode current density 10-20 asf. OFHC* copper anodes* or forged oval and/or balls. Cathode or solution agitation is desirable. ** Other PDL approved proprietary wetting agent may be substituted for DuPont 1085 if desired, in equivalent amount.
4.1.9 Rinse	Tap Water			room		Water should be free flowing
4.1.10 Dry						Dry with air blast, sawdust or cloths
4.1.11 Embrittlement Relief						Bake parts requiring hydrogen embrittlement relief per PR3-4

(CONTINUED)

TABLE I (CONT'D)

NOTE: 1	AVE.	RANGE	NOTE: 2 AVE.	RANGE
Copper (as metal)	2.5 oz/gal	2.0 - 3.0 oz/gal	5.9 oz/gal	5.6 - 6.2 oz/gal
Free Cyanide	1.1 oz/gal	.75 - 1.5 oz/gal	1.2 oz/gal	1.0 - 1.5 oz/gal
Potassium Carbonate	—	8.0 oz/gal max	—	8.0 oz/gal max.

Concentrations of copper and of free cyanide are controlled by additions of copper cyanide and potassium cyanide respectively, making allowance for the proper complexing factor.

* "OFHC" (Oxygen free high conductivity copper) Reg. U. S. Pat. Off. Amer. Metal Co. Ltd., N.Y, N.Y.

NOTE: 3 Copper Strike (Operation 4.1.6) is recommended before plating (4.1.8) to insure good adhesion of the deposit to the base metal. However the strike (4.1.6) may be omitted at the option of the plater providing adequate adhesion can be demonstrated per paragraph 5.4.

TABLE II

PROCEDURE FOR CLEANING, ACTIVATING AND COPPER PLATING SERIES 400 STEEL

4.2 OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION	TEMP F	TIME	CURRENT DENSITY AMPS/SQ/FT	DETAILS
4.2.1 Vapor Degrease						Per PR1-14 to remove grease, oil, etc.
4.2.2 Anodic Cleaning	Wyandotte F.S. Steel Cleaner or equivalent	8-14 oz/gal	185-200	90 sec minimum 120 sec maximum	75	Electrical contact should be made before immersing part in solution and not broken until parts removed.
4.2.3 Rinse	Tap Water		room	15 sec minimum		Water should be flowing
4.2.4 Anodic Activation	Sulfuric Acid	25 ± 2 % by volume	80 max.	45 sec minimum 60 sec maximum	50	Make electrical contact per 4.2.2.
4.2.5 Rinse	Tap Water		room	10 sec minimum		Water should be free flowing. Rapid transfer to Nickel strike is mandatory.
4.2.6 Nickel Strike	Nickel Chloride Hydrochloric Acid	30.0 ± 2 oz/gal 4.8 ± 0.2 oz/gal	80 max	110 sec minimum 130 sec maximum	50	Electrical contact, etc. as above 4.2.2. Use nickel anodes.
4.2.7 Rinse	Tap Water		room	15 sec minimum		Water should be free flowing. Rapid transfer to plating bath is mandatory.

References to Customer's Specifications, Technical Orders and other data are for information only and are not to be considered part of this specification.

TABLE II (Cont'd.)

PROCEDURE FOR CLEANING, ACTIVATING AND COPPER PLATING SERIES 400 STEEL

OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION	TEMP F	TIME	CURRENT DENSITY AMPS/SQ/FT	DETAILS
4.2.8 Copper Plate per 4.1.6 - 4.1.10 Table I	See Table I	See Table I	See Table I	See Table I	See Table I	See Table I
4.2.9 Embrittlement Relief						Bake in accordance with PR3-4 for parts requiring Hydrogen Embrittlement Relief

TABLE III

PROCEDURE FOR CLEANING, ACTIVATING AND COPPER PLATING, 300 SERIES STAINLESS STEELS, INCONEL AND INCONEL X

4.3 OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION	TEMP F	TIME	CURRENT DENSITY AMPS/SQ/FT	DETAILS
4.3.1 Vapor Degrease						Per PRI-14 to remove grease, oil, etc.
4.3.2 Cathodic Clean	Sodium Hydroxide Sodium Carbonate or RB0210-002 non silicated cleaner	2-4 oz/gal 1-2 oz/gal	140-150	90 sec min 120 max	100 min	Use steel anodes
4.3.3 Rinse	Tap Water		Room to 140	15 sec min		Water should be flowing
4.3.4 Anodic Activation	Phosphoric Acid	75 ± 2% (by volume)	80 max	90-120 sec.	75	Elect. contact made prior to immersion and not broken until part is removed. Use lead cathodes
4.3.5 Rinse	Tap Water		Room	15 sec min		Water should be flowing
4.3.6 Cathodic Activation	Sulfuric Acid	25 ± 2% (by volume)	80 max	15-30 sec.	50	Elect. contact made prior to immersion and not broken until part is removed Use lead anodes.

TABLE III (Cont'd.)

PROCEDURE FOR CLEANING, ACTIVATING AND COPPER PLATING 300 SERIES STAINLESS STEELS, INCONEL AND INCONEL X

OPERATION	SOLUTION CONSTITUENTS	CONCENTRATION	TEMP F	TIME	CURRENT DENSITY AMPS/SQ/FT	DETAILS
4.3.7 Rinse	Tapwater		Room	10 sec Min		Water should be flowing.
4.3.8 Nickel Strike	Nickel Chloride Hydrochloric Acid	oz/gal 30 ± 2 4.8 ± 0.2	80 max	110 sec min 120 max	50	Elect. contact made prior to immersion and not broken until part is removed. Use nickel anodes
4.3.9 Rinse	Tap Water		Room			Water should be flowing.
4.3.10 Copper Plate	per para 4.1.6 - 4.1.10 Table I					See Table I
4.3.11 Bake						Bake in accordance with PR3-4 for parts requiring Hydrogen Embrittlement Relief.

TABLE IV
PROCEDURES FOR STRIPPING COPPER FROM FERROUS ALLOYS, COPPER AND COPPER ALLOYS, SERIES 300 AND 400 STEELS

OPERATION	APPLICABLE PARTS	SOLUTION CONSTITUENT	CONCENTRATION	TEMP DEG F	CURRENT DENSITY AMP/SQ/FT	TIME SEC	OTHER DETAILS
1.1 Strip	Ferrous Alloys, Copper and Copper Alloys	Chromic Acid Sulfuric Acid (Subject to restrictions of PR3-4 or	4.0 lb/gal 7.0 oz/gal	room		Until Stripped	Dump and renew when necessary to obtain effective stripping
1.2 Strip	Series 400 Steel	ENSTRIP'S" or equivalent Sodium Cyanide	8 oz/gal 16-24 oz/gal	70-140		Until Stripped	Makeup and maintain per Suppliers instruction. Dump when necessary. See PR7-2 for precautions.
1.3 Strip	Series 300 Steel Inconel Inconel X, Inco 718	Nitric Acid	Conc	room		Until Stripped	Dump and renew when necessary to obtain effective stripping
2. Rinse	All	Tapwater		room		30 Min	Water should be flowing. Dry with air blast sawdust or cloths.

APPENDIX E

INSTRUMENT INSTRUCTION

Calibration for Hewlett Packard, Model 412A D.C. VTVM

Issued: 5/11/61

It is the purpose of this instruction to assure that the subject Vacuum Tube Voltmeters are accurate to within manufacturer's specifications.

DESCRIPTION

The Model 412A VTVM is a multipurpose instrument designed to measure DC voltage, current, and resistance over a wide range of values. Accuracies of these measurements are listed below.

	RANGES	ACCURACIES
Voltmeter	.001 to 1000 volts	± 1.0% of full scale
Ammeter	.000001 to 1.0 amperes	± 2.0% of full scale
Ohmmeter	0.1 to 0.2 ohms	± 10% of reading
	0.2 to 500 megohms	± 5% of reading
	500 megohms to 5000 megohms	± 10% of reading

In addition to these measurements, the HP 412A provides a DC amplifier output for use with a recorder. This output is one volt at full scale reading, and is proportional to the input for all other values.

EQUIPMENT NEEDED

1. Absolute DC Power Supply, 10 volt to 1000 volt range accuracy ±0.2%.
2. John Fluke, Model 801. Potentiometric voltmeter; or equivalent.
3. Decade resistors, 0.1 ohms to 1 megohm range, accuracy ±1.0%.
4. Precision resistors, range 0.1 through 5000 megohms, accuracy ±1.0%.
5. Variable DC supply capable of supplying 0.1 millivolts to 10 volts, at one ampere.
6. Variable transformer, General Radio variac or equivalent.

PREVENTIVE MAINTENANCE

Periodic preventive maintenance is not required of this unit.

CALIBRATION PROCEDURE

A. General Requirements

1. Electrical power to the test unit must have been on for at least 15 minutes prior to calibration tests.

B. Specific Requirements

1. Connect the VTVM to the variable transformer and adjust for 115V. Turn the power switch on.

CALIBRATION PROCEDURES (Continued)

2. Set the FUNCTION selector to VOLTS AND POLARITY switch to + (Plus).

3. Connect the VTVM and the John Fluke to the variable DC supply.

4. Set the RANGE switch to the 0.001 volt range.

5. Adjust the DC supply for a 0.1 millivolt reading on the VTVM.

6. Adjust the John Fluke for a null and take a reading. Reverse the DC input and VTVM polarity switch and note any difference in reading.

7. Repeat this procedure at one-tenth or one-third of full scale increments, for all ranges, through the 10 volt range.

8. Disconnect the variable DC supply and the John Fluke, and connect the VTVM to the absolute DC power supply.

9. Check the VTVM readings against the absolute DC power supply dial set through the 1000 V scale, following the procedure listed in step 7.

10. All readings taken must be within the accuracies listed on page one.

11. Disconnect the absolute power supply.

12. Set the FUNCTION selector to MA and POLARITY switch to + (plus).

13. Connect the variable DC supply, a decade resistor and the VTVM in series, and connect the John Fluke across the DC supply.

14. Adjust the variable supply for 0.1 volt and set the decade resistor for one megohm. VTVM should read 0.1 microamp. Reverse the polarity of the VTVM and DC source and note any difference in reading.

    NOTE: DO NOT EXCEED THE MAXIMUM CURRENT RATING FOR THE DECADE RESISTANCE USED.

15. Adjust the variable supply and decade resistor for current readings of one-tenth or one-third of full scale increments for all scales.

16. All readings taken must be within the accuracies listed on page one.

17. Set the FUNCTION selector to OHMS.

18. Measure the precision resistors with the VTVM. All VTVM readings must be within the accuracies listed on page one.

19. Set the FUNCTION switch to VOLTS, and the RANGE switch to the one volt range.

CALIBRATION PROCEDURES (Continued)

20. Connect the variable DC source to the VTVM and adjust for a full scale reading.

21. Connect the John Fluke to the OUTPUT terminals and measure the output. Amplifier output must be one volt within ±1%.

22. Adjust the variable DC supply to various scale points. Output readings must proportional to scale readings.

In the event the unit does not meet the requirements of this instruction, refer to the operating and servicing manual for necessary adjustments and repairs.

R. J. Schultz
Metrology Standards Unit

WSC____________

D. L. Bott - Supervisor
Metrology Standards Unit
Production Development Laboratory

RJS:DLB:sr

APPENDIX F

STAMP CATALOG

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.

QUALITY CONTROL OPERATING PROCEDURE

Dept. and Plant: INSPECTION DEPARTMENTS ALL ROCKETDYNE PLANTS

TITLE: STAMP CATALOG

Date: 12 JAN 1960

Approval Robert L. Stath

GENERAL

The correct use of stamps to indicate inspection status of a product is the responsibility of Quality Control Supervision and the individual inspectors. Engineering Drawings or Process Specification FA 606-2 shall dictate when a part is to be metal impression stamped.

It will be noted that Neosho and McGregor inspection stamps will have a letter designation to prefix the stamp number. Neosho stamps will be identified by the letter "A" to prefix the stamp number. McGregor stamps will be identified by the letter "S" to prefix the stamp number.

The following facsimiles of the types of stamps are presented for general information and guidance:

1. ACCEPTANCE STAMPS

1.1 Used to indicate dimensional and functional inspection on products that cannot be steel stamped. Plastic, sizes 7/16" and 1" x 1". Fig. 1.

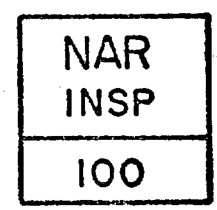


Fig. 1

1.2 Used on parts and paperwork to indicate dimensional and functional inspection. Plastic, size 1/4". Steel, sizes 1/8" and 1/4". Fig. 2.

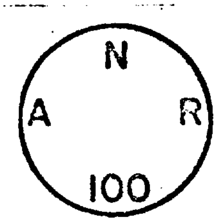


Fig. 2

1.3 Used by Receiving Inspection exclusively, for stamping raw stock, purchased products, receiving reports, packing sheets, etc. Plastic, sizes 1/2" and 1". Steel, sizes 1/4" and 1/8" Diameter. Fig. 3.

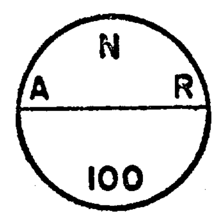


Fig. 3

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*Supersedes R-2.3.1 dated 16 Oct. 1953.

1.3.1 All Receiving Inspection Acceptance stamps indicate that the product so stamped complies with the requirements of applicable drawings or specifications and has been functionally tested if required. Processes performed will be identified by the applicable stamps i.e. X-ray, H.T., H.T.A., Mag., Ultra., and Penetrant.

1.4 The PHI symbol identifies parts or assemblies to be used by Research and Development. The PHI stamp will be affixed to parts or assemblies after inspection. Fig. 4.

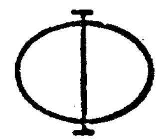


Fig. 4

1.5 The rectangular acceptance stamp is used by Inspection Supervision only. The stamp is applied by placing the rectangle over the PHI stamp indicating the part is acceptable for production use. The number on the stamp identifies the individual to whom it is issued. Fig. 5.

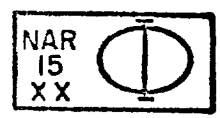


Fig. 5

1.6 Used to indicate parts have been water washable fluorescent Penetrant inspected and identify certified operator. Steel, sizes 1/8" and 1/4" Diameter. Plastic, size 1/4" Diameter. Fig. 6.

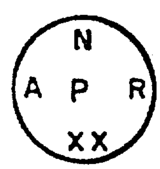


Fig. 6

1.7 Used to indicate parts have been Post Emulsified Fluorescent Penetrant inspected and identify the certified operator. Steel, sizes 1/8" and 1/4" Diameter. Plastic, size 1/4" Diameter. Fig. 7.

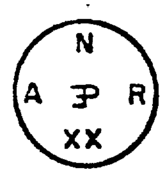


Fig. 7

1.8 Used to indicate parts have been Dye Penetrant inspected (Kits) and identify the certified operator. Steel, sizes 1/8" and 1/4" Diameter. Plastic, size 1/4" Diameter. Fig. 8.

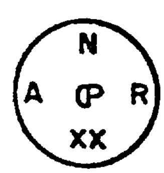


Fig. 8

1.9 Used to indicate parts have been Non-Liquid Oxygen (LOX) Sensitive Penetrant inspected and identify the certified operator. Steel, sizes 1/8" and 1/4" Diameter. Plastic, 1/4" Diameter. Fig. 9.

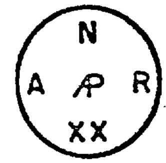


Fig. 9

1.10 Used on connectors and tags attached to electrical assemblies to indicate acceptance of soldering. Fig. 10.

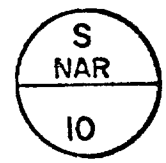


Fig. 10

1.11 Used on connectors and tags attached to electrical assemblies to indicate continuity acceptance. Fig. 11.

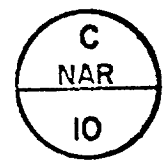


Fig. 11

1.12 Used to indicate the weld was accomplished by a certified weldor who is identified by the number on the stamp. Fig. 12.

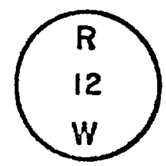


Fig. 12

1.13 Used to indicate that a seam weld or a spot weld has been accomplished. Fig. 12A.

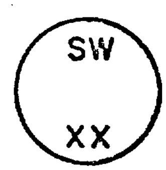


Fig. 12A

2. MATERIALS REVIEW STAMPS

2.1 The withholding "D" stamp on parts and paperwork indicates items very from drawings or specifications and require Materials Review action. Stamps are issued to Materials Review Board members and Inspection Leadmen. Steel, sizes 1/4" x 5/16" and 1/8" x 3/16". Plastic, size 1/2" x 5/8". Fig. 13.

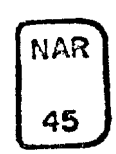


Fig. 13

2.1.1 The "D" stamp is not to be used when parts may be reworked to meet original Engineering requirements, reworked or accepted per a Standard Repair, or being returned to the supplier.

2.1.2 Discrepant Purchased items will be "D" stamped, triangle stamped, only after a decision has been made to accept them.

2.2 Materials Review acceptance stamp is used to indicate acceptance of a specific discrepancy. For stamping parts and paperwork and is applied by interlocking the "D" stamp. This stamp is issued only to Inspection Supervision and Materials Review Board Members on approval from the Materials Review office. Steel, sizes 11/32" x 11/16" and 5/32" x 11/64". Plastic, sizes 5/8" x 11/16" and 5/16" x 11/32". Fig. 14.

Fig. 14

2.3 Materials Review rejection stamp for application on any scrapped item and applicable paperwork. Issued only to Inspection Supervision and Materials Review Board Members on approval from the Materials Review Office. Steel and Plastic, sizes 1/2" x 5/8" and 1/4" x 5/16". Fig. 15.

Fig. 15

2.3.1 The "R" stamp is applied on withheld items and identifies them as being irreparable and unfit for production use. The "R" stamp may be used on detail parts returning to suppliers under the following conditions:

2.3.1.1 When parts are of Rocketdyne Design.

2.3.1.2 When parts have discrepancies that are the supplier's responsibility and are not acceptable as is.

2.3.1.3 When rework of the parts, by the supplier, to meet original requirements is impossible.

2.3.1.4 When rework of parts, by the supplier, to any other configuration, by any method, will not be acceptable to Rocketdyne.

2.3.1.5 When removal of stamp by Materials Review, if necessary, will be possible without destroying the usefulness of the part.

3. X-RAY STAMPS

3.1 X-ray stamp used by X-ray Laboratory Technicians on parts that have been radiographic inspected. Steel and Plastic. Fig. 16.

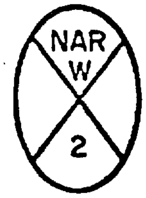


Fig. 16

3.2 X-ray reject stamp used by X-ray Laboratory Technicians on items that have failed Radiographic Inspection and are not reworkable. Steel and Plastic. Fig. 17.

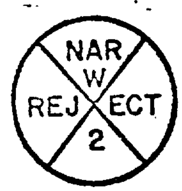


Fig. 17

4. TEST STAMPS

4.1 Used by all Inspection sections on sheet metal parts .032 gauge and under to indicate the item has been heat treat inspected. Steel and Plastic. Fig. 18.

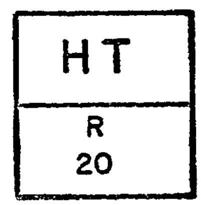


Fig. 18

4.2 Used on parts to indicate they have been heat treat inspected. Steel and Plastic. Fig. 19.

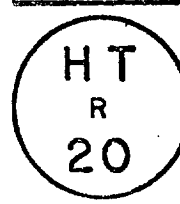


Fig. 19

4.3 Indicates heat treat aging process has been accomplished on 75S material of large size. Plastic. Fig. 20.

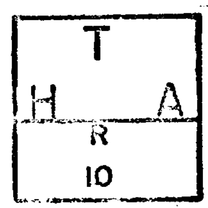


Fig. 20

4.4 Indicates heat treat age on small 75S parts and materials. Used also on applicable paperwork. Steel and Plastic. Fig. 21.

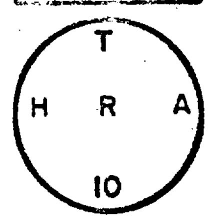


Fig. 21

4.5 Used by Production Development Laboratory personnel to indicate that an operation has been performed or a test has been passed. Steel and Plastic, for stamping parts and paperwork. Fig. 22.

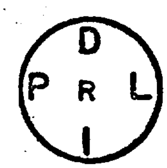


Fig. 22

4.6 Pressure test stamp indicates item has been satisfactorily pressure tested to drawing or specification requirements. Applied to parts and paperwork. Fig. 23.

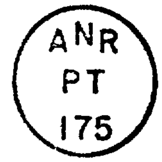


Fig. 23

4.7 Preliminary magnetic inspection stamp indicates accomplishment of progressive magnaflux operation as required by Planning Ticket. Do not confuse with final magnaflux acceptance stamp, paragraph 4.8. Fig. 24.

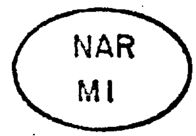


Fig. 24

4.8 Magnetic inspection acceptance stamp indicates that products and paperwork so stamped have been magnafluxed inspected. The stamp number identifies the certified operator. Steel and Plastic. Fig. 25.

Fig. 25

4.9 Identifies the yoke and powder method of magnetic particle inspection. The stamp number identifies the certified operator. Plastic 3/8" Diameter. Fig. 26.

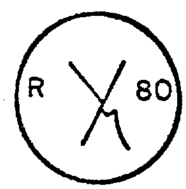


Fig. 26

5. INFORMATION AND IDENTIFICATION STAMPS

5.1 Supplier ultrasonic inspection stamp indicates ultrasonic inspection has been performed in accordance with CD-3211. The number identifies the source. Steel and Plastic. Fig. 27.

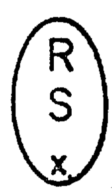


Fig. 27

5.2 Rocketdyne (Canoga) supplier or subcontractor identification stamp. The number identifies the supplier. Steel and Plastic. Fig. 28.

Fig. 28

5.3 Steel parts that have been hardness tested after heat treat by a supplier and meets drawing requirements, will be identified with this stamp. The number identifies the source. Steel and Plastic. Fig. 29.

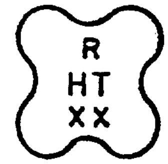


Fig. 29

5.4 Aluminum parts that have been hardness tested after solution heat treat by a supplier and meets drawing requirements, will be identified with this stamp. Steel and Plastic. Fig. 29.

5.5 Aluminum parts that have been hardness tested after precipitation hardening (aging) by a supplier and meets drawing requirements, will be identified with this stamp. Steel and Plastic. Fig. 30.

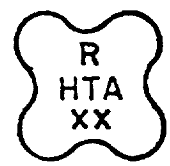


Fig. 30

5.6 Aluminum alloys which do not require precipitation hardening (aging) 2024 (24S), 2017 (17S), and have been hardness tested after room temperature aging and meet drawing requirements, will be identified with this supplier stamp. Steel and Plastic. Fig. 31.

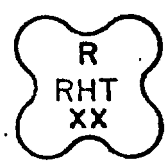


Fig. 31

5.7 Rocketdyne (Neosho) supplier stamps will have an "R" at the top of the stamp and an "A" prefix to the number. Steel and Plastic. Fig. 32.

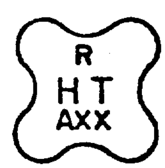


Fig. 32

5.8 This stamp is used by production leadmen. The number on right identifies the employee. The number on the left indicates the department. Fig. 33.

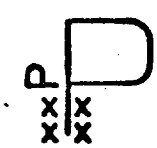


Fig. 33

5.9 Dept. of Defense Stamp used by the customer. Fig. 34.

Fig. 34

5.10 This stamp indicates that the applicable part or assembly has been balanced in accordance with drawing or specification requirements. Fig. 35.

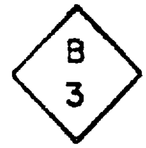
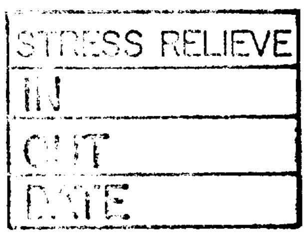


Fig. 35

5.11 Used by production inspection to indicate stress relieve. Applied on parts and paper work. Fig. 36.



STRESS RELIEVED

Fig. 36

5.12 This stamp indicates part has been etched. Applied on part and paper work. Fig. 37.

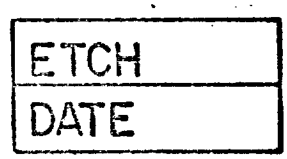


Fig. 37

5.13 This stamp indicates the part has had a baking process performed and is applied to paper work. Fig. 38.

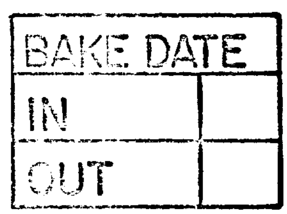


Fig. 38

5.14 The Omega Symbol identifies F-1 parts in components category to be used by Research and Development. The Omega stamp will be affixed to components after acceptance by inspection and presented to Dept. 596 stores. Fig. 39.

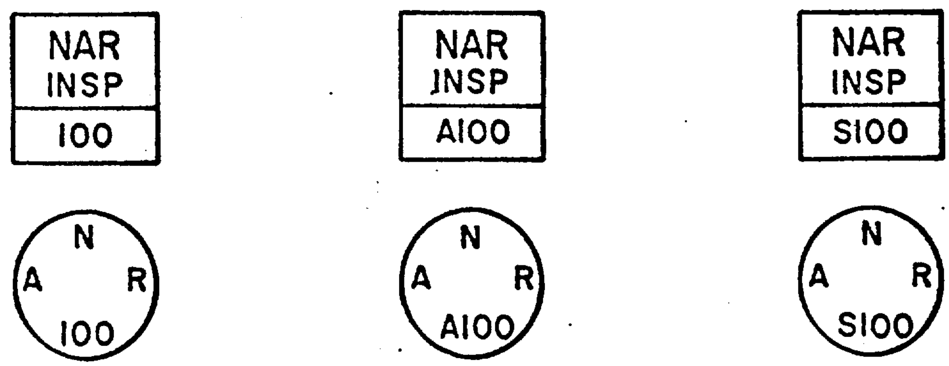
Fig. 39

NOTE: Divisional identification will be indicated by the following code letters which are incorporated into the stamp design:

- A - Autonetics
- H - Columbus
- L - Los Angeles
- M - Missile Development
- R - Rocketdyne
- N - Atomics International (except inspection acceptance and materials review stamps)

6. A typical acceptance stamp for the three plants is illustrated below:

6.1 Canoga Neosho McGregor



6.2 A survey reveals that the illustrated stamps, herein noted by Fig. No., are the ones requiring a letter prefix for Plant identification:
Figure Numbers are - 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 23, 24, 25, 26, and 35.